



TECHNOLOGY OF DAIRY PRODUCTS

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Technology of Dairy Products

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Disclaimer

Science and technology are constantly changing fields. New research and experience broaden the scope of information and knowledge. The authors have tried their best in giving information available to them while preparing the material for this book. Although, all efforts have been made to ensure optimum accuracy of the material, yet it is quite possible some errors might have been left uncorrected. The publisher, the printer and the authors will not be held responsible for any inadvertent errors, omissions or inaccuracies.

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*To our Mothers
Who introduced us to Milk, before any Teacher did.*

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FOREWORD

Milk is considered an ideal food for neonates, adolescents, adults and geriatrics, hence every attempt has been made to preserve this wholesome food by various processing operations. In the recent years through biotechnological innovations, the focus of attention has been on improving the quality, nutritional and functional attributes of foods and also minimizing the processing and post harvest losses. Recent advancements in biotechnology have offered the opportunity not only to control the existing food processes in better way, but also to adopt entirely novel approach for quality control and newer product development. The potential of this new-fangled technology is enormous but its true economic impact has yet to be realized.

Growing awareness towards the beneficial role of milk and milk products in maintaining human health has led to the development of wide range of novel functional foods, health foods, nutraceuticals, mood elevating and refreshing foods. Further few components, such as immunoglobulins, lactoperoxidase, lactoferrin, and lysozyme derived from milk play an extra nutritional role. The dairy industry in advanced countries is rapidly diversifying its product mix to produce a range of foods that are targeted to reduce the use of medicines in human. There is vast opportunity for development of new milk products and improving their functional and nutritional attributes by the application of biotechnology that enable the food processors to improve the shelf life, acceptability and nutritive value of foods.

The rapid growth and advancement in processing technologies in the recent years, has also changed the demand of consumers. Further, increased population with the growing trend towards urbanization would bring several demographic changes in our society. There is going to be an ever increasing demand of milk and milk products in India and progressively higher production with improved standards in terms of hygiene, safety and quality of food products will be demanded.

This book, "Technology of Dairy Product" by Dr. J.V. Parekh and Dr. M.L. Naware, specifically designed for dairy and food professionals has all relevant information on processing principles, technologies for industrial production, packaging, nutrition and health, and market surveys and statistics. The given 26 chapters deal with the salient aspects of the processing and manufacture of various types of milk products including Indian traditional and western dairy products, maintenance of dairy machinery, standards and specifications of various products, dairy calculations and formulations, etc. I am sure that dairy entrepreneur, dairy professionals and students would find it very useful, during establishing a dairy or at latter stage while expanding it. Further in this book, many other newer aspects have also been effectively embraced, which deserves appreciation, as it may provide the futuristic expansion and sustainability of dairy and food industry in our country.

I wish all the best.

Prof (Dr.) A. K. Srivastava
Director & Vice Chancellor
National Dairy Research Institute,
Karnal-132 001(Haryana)

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MESSAGE

The book entitled "**Technology of Dairy Products**" covering various aspects of milk processing technology including manufacturer of various milk products authored by Dr. J. V. Parekh and Dr. M. L. Naware is most useful reference publication for professionals, entrepreneurs, scientists and research scholars who are in dairy sector. This book will be useful as a reference in the production of high quality milk and milk products to satisfy consumer's demand and also to ensure food safety measures.

Today, India is number one in milk production globally. In order to encourage dairying on commercial lines and to compete internationally in quality for export of various milk products, there is a need to disseminate the hidden knowledge and experiences among the practitioners as well as the new entrants. I feel that the compilation in its present form will facilitate understanding the processing of milk and milk products and quality concepts and their use in addressing the operational problems that are being faced by the professionals in the industry.

Dr. J. V. Parekh and Dr. M. L. Naware have made a significant and notable contribution in bringing out this publication by putting lot of facts and figures on various aspects of milk processing. This technical and informative publication will help for better planning and utilisation of existing facilities and also for expansion of the Dairy plants. The book on "Technology of Dairy Products" which is in a simple language will be useful for professionals, students and plant operators who are involved in day-to-day functioning of the dairy industry.

I extend my warm greetings and best wishes for all success.



Dr. K. R. Rao, Ph.D.
Former Chief General Manager
NABARD, Mumbai

16th October 2012

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MESSAGE

I have great pleasure in writing this foreword for the book entitled "Technology of Dairy Products" by J.V.Parekh and M.L.Naware, which has especially been written for entrepreneurs. I congratulate them on this excellent contribution.

A good reference book covering the entire gamut of dairy technology at an affordable price is not available today. This contribution is very timely when large number of entrepreneurs is looking forward to venture in to dairy processing sector. The authors have taken tremendous pains in preparing this book focusing attention on basics as well as applied aspects of milk processing yet keeping simplicity and readability that would help any beginner enjoy reading and understanding.

This book has been very thoughtfully divided into 25 chapters covering manufacture of various indigenous and western dairy products, the maintenance of dairy machinery, standards and specifications of various dairy products and other useful information which may be required by a dairy processor. It deals with the salient aspects of the processing and manufacture of various types of milks and milk products. Richly illustrated by diagrams, graphs, tables and charts on materials, process, machines, products, etc., this book provides excellent presentation. A unique feature of this book is that each chapter gives finer details of almost all aspects with inclusion of what is normally thought as trivial in greater details for the variety of dairy processes, which should go a long way to help the readers understand the subject thoroughly.

This book carries the rich experience of the authors in industrial and consultancy activities, which is reflected in every line of the book.

I am confident that dairy entrepreneurs, their advisers, suppliers of dairy inputs including dairy financiers, who master the concepts and approach explained in this book, could not fail to find ways to increase the productivity and profitability of dairy enterprise. This book, Technology of Dairy Products, is a valuable addition to the literature about dairy technology. I recommend this book for all in this field.

G.R.Patil
Joint Director (Academic)
Indian Veterinary Research Institute,
Izatnagar, Bareilly, UP.

PREFACE

The present scenario of dairying in India is promising in many ways. The milk production has touched 114 million metric tonnes per annum which continues to place us on number one position in the world. In Asian context we produce over 15 per cent of the total production which gives us leadership position. The per capita milk availability in India has reached 260 gms per day against world average of 265 gms and programmes are on way to step up the production commensurate to increasing demands with rising income levels at home.

However, having said this if one thinks that India is fully developed country in terms of dairy development, it is far from truth ! We still have to go a long way to increase productivity per milch animal to bring it any closer to international level; create disease-free environment for dairy export purpose; produce much better quality milk for our own people, increase milk processing capacity to produce milk and milk products under total quality management and reach to a much larger segment of our population than ever before. This can be further substantiated by citing the fact that only 30 percent of milk presently produced in India is handled in organised sector which includes all the dairy plants in Co-operative, Government and Private sector. The other significant feature is that within the 30 per cent by the private sector, the cooperatives and government dairies handle 10 per cent or 12 ml of milk, which is lower than that of the organized private sector. Hence, there is urgent need to increase this percentage to safeguard the health of our children and other consumers by offering them processed milk.

On this background, it is heartening to see the changes that have taken place in the last two decades. Gone are the days when establishing a dairy was prerogative of the Government or a Co-operative. Now, we are in a situation when there are more number of dairy plants and more installed capacity in the private sector than in the remaining sectors. And this trend continues with further promising arrangements like public-private partnerships etc. What more, the entrepreneurs are crossing state borders and establishing milk processing plants finding new horizons. This has been possible only because of new era of globalisation, liberalization and privatization.

Every entrepreneur, while entering a new business or while doing it at a new location needs proper advice and dairy business is no exception to that. However, it has been our experience that a new entrant in dairy business has often faced a situation where he had no proper advice and had to learn from his own mistakes or close down the business or look for somebody to buy it. The trend unfortunately still continues and we felt that it could be arrested if an entrepreneur gets proper advice before venturing in to this business. Also since dairy industry in India is fast developing on the industrial front, it is considered highly desirable by the

authors to compile and present the available information on the technical aspects of dairy products in the form of a small publication

One way of getting proper advice or first hand information is through book. While hundreds of books may be available on various aspects of dairying we felt that a book for guiding the entrepreneur may be what is necessary. With this aspect in view we decided to present the subject matter. This book deals with the manufacture of various indigenous and western dairy products, the maintenance of dairy machinery standards, specifications of various dairy products and other useful information which may be required by a dairy processor. It deals with the salient aspects of the processing and manufacture of various types of milks and milk products. The text has been supplemented with illustrative problems and their solutions, and includes photographs of some of the equipment used in the dairy industry..

It is our hope that the entrepreneur and the dairy professional/s helping him would find it useful, be it in the premature stage, during establishing a dairy or at latter stage while expanding it. The book also covers the new technologies and concepts which the entrepreneur is ought to know since they are the order of the day.. We are aware this may not contain answers for all of their questions for which invariably they may have to seek for an advice from a specialist whose role can never be undermined. It is hoped that this publication will be of great interest to new entrepreneurs as well as the industrialist who are already in the field

In the preparation of this book the authors had the privilege of drawing material freely from various research papers, and annual reports. The authors are grateful to several research workers and authors of different theses as well as the editors of various technical journals/books which are too numerous to be named individually for most of the information presented in this book. Comments and criticism from readers on any aspect of the book will be thankfully received for further improvement of this work.

Dr. J. V. Parekh
Dr. M. L. Naware

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Abbreviations

ACE	Angiotensin Converting Enzyme
AHU	Air Handling Units
ADPI	American Dry Products Institute
BIS	Bureau of Indian Standards
BOD	Biochemical Oxygen Demand
Ca(OH)	Calcium Hydroxide
CaO	calcium oxide
CIP	Cleaning-In-Place
CO ₂	Carbon Dioxide
COD	Chemical Oxygen Demand
COP	Co-efficient of Performance
°C	Degree Celsius
cm	Centimeter
DC	Direct Current
DF	Diafiltration
Dm ³	Desicubic meter
dl	delilitre
FDM	Fat in dry matter
FSSA	Food Safety and Standard Act
gm	Grams
GP	Grease Proof
GMP	Good Manufacturing Practices
HH	High-Heat
HHP	High Hydrostatic Pressure
HIPS	High Impact Polystyrene
HPP	High Pressure Processing
HPWP	Heat-Precipitated Whey Protein
HTST	High Temperature Short Time
HDPE	High Density Polyethylene

IBR	Indian Boiler Regulation
IBT	Ice Bank Tank
IDP	Indigenous dairy products
L/Lit	Litre
LF	Lactoferrin
LH	Low-Heat
LP	LactoPeroxidase
LTLT	Low Temperature Long Time
m	Meter
mg	milligram
ml	millilitre
mm	millimeter
m ³	Cubicmeter
MAP	Modified Atmosphere Packaging
MF	Microfiltration
MFFS	Moisture-in-fat Free substances
MgO	Magnesium Oxide
MH	Medium-Heat
MLSS	Mixed Liquid Superior Solids
MMPO	Milk and Milk Products Order
mpa	milli Pascal
MBR	Methylene Blue Reduction
N	Normality
Na ₂ CO ₃	Sodium Carbonate
NaOH	Sodium Hydroxide
NDDB	National Dairy Development Board
NDRI	National Dairy Research Institute
NF	Nanofiltration
NPC	National Productivity Council
NPN	Non Protein Nitrogen
OH	Ohmic Heating

PEF	Pulsed Electric Field
PHE	Plate Heat Exchanger
PPCP	Polypropylene Co primer
PLC	Programmable Logic Control
PH	Negative Logarithmic of Hydrogen Ion Concentration
ppm	Parts per million
Psi	Per Square Inch
RO	Reverse Osmosis
RPM	Revolution Per Minute
S	Seconds
SCC	Spinning Cone Column Technology
SMP	Skim Milk Powder
SNF	Solids-Non Fat
SSHE	Scraped Surface Heat Exchanger
Sp.gr	Specific gravity
TS	Total Solids
TDS	Total Dissolved solids
UASB	Upflow Anaerobic Sludge Blanket
UF	Ultrafiltration
UHT	Ultra High Temperature
UTP	Uniform Transmembrane Pressure
WPC	Whey Protein Concentrate
WPNI	Whey Protein Nitrogen Index

Chapter 1

Introduction

Brief History of Dairying

Preamble: The dairy industry as we see today covers the production, processing and distribution of milk and milk products. It is unique in its importance as it is concerned with valuable foodstuffs universally consumed by people. At the same time it deals with a produce which is highly perishable due to its high nutritive value and fluid nature that makes it an ideal medium for growth of bacteria. Every person in dairy industry has to remember this aspect and avoid contamination of milk, and follow healthy practices at every level. One has to eliminate unhealthy cattle from dairy herd, employ sanitary conditions for milking, cool the milk during procurement and transportation, use sterilised containers and pasteurize the milk before distribution.

History

The history of dairying dates back to ten thousand years or so, when several animals including cow were domesticated by man in southwestern parts of Asia. The idea of using milk from cow, sheep and goat also originated from this area to the other parts of the world. The art works in the caves found in present day Iraq, Syria and Turkey depict the milking of cows and use of vessels. There are references in Vedic literature in Sanskrit (6000 years B.C.) regarding milk, butter and curd. In the epic Mahabharat, there is ample description of Mathura and Gokul where prosperity was linked to the ownership of cows and availability of milk, butter and curd. In Egypt, cow's milk, butter and cheese were in use 3000 years B.C. whereas Greeks were using milk and cheese obtained from goats and sheep by and large. The ancestor of present day ice-cream was an iced-sweet made from mixing snow and fruit juice by Chinese 3000 years B.C. whereas Alexander the Great is said to have enjoyed mixture of honey, fruit juice and milk frozen in hard packed snow carried by relays of slaves from the mountains.

Last 250 Years

However, the dairy industry as we see today has developed just over last 250 years. Before the year 1850, the dairying was limited to the family level in most of the countries. The surplus milk was sold from villages to the cities by carrying it on the carts. As the cities turned into large consumption centres and with the onset of industrial age there was boost to development of dairying on factory scale. The continuous cream-separator was developed by Gustar de Laval in the year 1778, whereas in 1856 milk powder was produced for the first time. During next 100 years the tempo continued. The technology

of preserving milk by cooling was developed during 1880-90 which facilitated carriage of milk over long distance without spoilage. During 1888, Nicholas Gerber in Germany and in 1890 Babcock in USA developed the test for measurement of fat in milk which since then has become the basis for deciding payment for milk. The technology for pasteurization of milk was developed in 1895 which enhanced its shelf life while also killing the disease causing germs by and large. This helped many countries to pass a law that prohibited sale of unpasteurised milk. Chicago was the first state in USA where such Act was introduced in 1908. The first vehicle with an insulated milk tanker started running on the road in 1914. As a result of all this technological advancement the dairying has developed across the world. During last sixty years it has achieved phenomenal growth with newer and newer methods and their application.

Present Status of Dairying: An Overview

Global Dairy Situation: Due to continuous selection of the animals made by farmers and the efforts of Cattle Breeders Associations, high-yielding cow breeds have been developed over last hundred years. By and large two breeds viz., Holstein Friesian and Jersey have become most popular. Although these breeds originated from Holland and Jersey (in Europe) respectively, now they are known after the country they belong to. The Israeli Friesian cows for example produce average 11292 litres of milk per lactation which is almost double the amount produced by cows in Europe. In USA, the average cow produces 9053 litres of milk per lactation.

It is estimated that during 2009 the total milk production all over the world was 711 million tons with annual growth rate between one and three percent. The cow milk production at 604 million tons constituted almost 85 percent of the total production. The production of buffalo milk is estimated at 92.5 million tons which is 13 percent of the total production. It is to be noted that 90 percent of the world's buffalo milk is produced in India and Pakistan. Further, the growth in cow milk production has slowed down whereas, buffalo milk production has registered faster growth rate.

In developed countries the dairy farms are large in size where cows are milked by machines and stall-fed except in New Zealand where they are raised on pastures. In these countries milk is consumed more in the form of cheese, butter, Ice-cream, etc. It is estimated that more than thirty percent of the total milk produced in the world gets converted into cheese. Europe has a share of over 58 percent in the world's cheese production and the conversion figures are rising every year. The countries with their annual cheese production and per capita consumption is given in **Annexure – I**. Apart from cheese and butter, large volumes of milk are converted into whole milk powder, skimmed milk powder and all these products are traded world over. It is interesting to note that New Zealand which produced hardly 10 million tons of milk per year, which is just 1.5 percent of the world's milk, exports more than 95 percent of its milk in the form of products numbering more than 800 !.

Dairying in India: India has now emerged as the country that produces maximum quantity of milk in the world. It's estimated milk production has reached 121.8 million tons in 2010-11 with per capita availability of 269 gms per day. However, the bulk of this milk is produced in rural areas by millions of farmers with medium or small land holdings and even by Landless. The number of well recognised cow breeds in India is about 30 and there is wide variation in their ability to produce milk. Many of these breeds are actually famous for producing powerful bullocks for farming. However, few are recognized for milk production as well. In addition, a large number of cows which do not conform to any definite breed characters are called as nondescript.

They are poor producers of milk but as they are maintained at little cost they are also used for obtaining milk. Over last fifty years millions of these cow have been crossed with the Holstein and Jersey breeds through the technique of artificial insemination. Indeed, these efforts have helped our country to increase its milk production to the present level. The buffalo is generally regarded as the dairy animal of India. There are 8 recognised breeds of buffaloes in India and Pakistan. The names of Indian breeds of cows and buffaloes, their home tract and average milk yields are given in **Annexure – II**. Similarly the top 12 milk producing states and their share is and their total milk production is shown in **Annexure – III**. However, it is to be noted that average milk production per animal in India is very low at around 1100 litres per lactation. The goat is also popular in India and considered as poor man's cow. About 18 percent of the goat population is used for milk production.

A large quantity i.e. about 46 percent of the milk produced in India is consumed at source. Of remaining 54 percent marketable surplus, a large chunk (over eighty percent) is collected by private sector and converted into khoa, channa, paneer, and ghee apart from sale as milk. It is estimated that only 30 percent of the marketable surplus is procured by organised dairies in cooperative, Govt. and private sectors. Production being scattered over a wide area, the cost of collection and transport is often prohibitive in several areas. Generally cow milk is preferred for consumption as milk and buffalo milk for preparation of milk products. Almost as a rule milk in India is boiled in all households before it is put to any use.

Under a massive dairy development programme of Operation Flood, a vast network of 1,15,000 Dairy Cooperative Societies has been created with formations of 170 district level Milk Unions with their own dairy plants and 22 State Cooperative Federations. With the new economic policy launched in nineties a large number of dairy plants have been set up in private sector as well. The number of dairy plants registered in India as on 31.3.2011 was 1065 of which 263 are in cooperative sector, 765 are in private sector and 37 are others as per registration granted under Milk and Milk Products Order of Govt. of India. These dairy plants are engaged in processing and distribution of packed milk other than production of variety of milk products. Dairy Products like

milk powder, butter, condensed milk, cheese, dahi, etc. are manufactured on a significant scale and figure in inter state trade. Milk is also used in a big way in production of sweetmeats which is a lucrative business mostly in traditional sector.

In the next chapter definitions and general description of milk and milk products are covered.

Chapter 2

General Description of Milk and Definitions of Milk and Milk Products

Historically milk is considered as a perfect food with right mix of nutrients and ideal caloric density capable of nurturing life for children as well as adults of all ages. Except for iron and vitamin D, milk provides practically all the nutrients required for normal growth.

Table 2.1: Nutritive Values of Milk

Nutrients	Buffalo milk	Cow milk	Goat milk	Human milk
Protein (gm)	4.3	3.2	3.3	1.1
Fat (gm)	6.5	4.1	4.5	3.4
Carbohydrate (gm)	5	4.4	4.6	7.4
Energy (kcal)	117	67	72	65
Calcium (mg)	210	120	170	28
Phosphorous (mg)	130	90	120	11
Iron (mg)	0.2	0.2	0.3	NA
Thiamine (mg)	0.04	0.05	0.05	0.02
Riboflavin (mg)	0.10	0.19	0.04	0.02
Vitamin C (mg)	1	2	1	3
Vitamin B12 (mcg)	0.14	0.14	0.05	0.02

For our active life, milk is a powerful source of calcium and eight other essential nutrients that keep us energized throughout day. While known for its calcium, milk actually contains a nutrient package that is great for our bodies. Each 200 ml glass of milk provides various nutrients in the following percentages of an adult's daily-recommended requirement:

30% of calcium to help build and maintain bone mass.

25% of vitamin D to help promote the body's use of calcium and encourage absorption of other essential minerals.

24% of riboflavin, a type of vitamin B that helps to convert food into energy.

20% of phosphorus to help strengthen bones and generate energy in body cells.

16% of protein for building and repairing muscles.

13% of vitamin B 12, an essential vitamin for building oxygen-carrying red blood cells.

11% of potassium for regulating the body's fluid balance and maintaining normal blood pressure.

10% of niacin or niacin equivalents for assuring the normal functioning of many enzymes and the metabolism of sugars.

10% of vitamin A to help maintain normal vision and skin.

The three major catastrophic events in the lives of population in industrially developed countries like the US are the rapid rise in osteoporosis, cardio-vascular disease and obesity over the last few years and many reasons have been attributed to such undesirable developments. These include sedentary living styles, imbalance in the diets, lack of physical exercise, increasing pressure on time. Osteoporosis is caused mainly due to inadequate uptake of calcium in the diet resulting in development of bones with low bone mass, and it has been proved that popping calcium pills is no substitute to regular intake of bio-available calcium from natural sources. Calcium intake by the human system is through such foods like dairy products, vegetables and cereals and also from hard water. Among these, dairy products are the major source of calcium often referred to as 'dairy calcium'. It has been well established that optimum calcium intake can not be achieved without milk or dairy products because dairy calcium is easily absorbed by the intestine. Dairy calcium is considered to have a higher bioavailability than calcium in vegetables, cereals or other sources. Calcium content of breast milk is about 28 mg/dl, while cow's milk has 114 mg/dl and buffalo milk 180 mg/dl and the bioavailability is more than 85%. Recent studies have confirmed the role of dairy calcium as unique in preventing such debilitating diseases like osteoporosis, hypertension and cancer. Dairy calcium also is reported to provide protection to the teeth by way of aiding demineralization of damaged enamel following bacterial acid production.

The wide range of proteins that are present in milk seems to be possessing some extraordinary biological and physico-chemical properties beneficial to humans. Some of the breakdown products from these proteins include short chain peptides often considered possessing bioactive properties. Many of them are physiologically active molecules and their structures are similar to human hormones. They are endowed with many desirable properties, which include modulating metabolic processes, like digestion, immunological responsiveness, cell growth and repair, and nutrient absorption. Some of the milk peptides are found to have inhibitory activity on Angiotensin Converting Enzyme (ACE) thereby reducing blood pressure, and hence dairy foods are natural functional foods for controlling hypertension. Milk proteins and their enzyme hydrolyzed peptide derivatives are implicated in many other beneficial roles as they possess opioid activity, antimicrobial activity, anticancer activity, antimutagenic activity, immuno-stimulatory activity, antithrombotic activity, antigestric activity, etc.

One of the most startling findings reported some time ago claim that milk, contrary to the conventional belief, turns down the tendency of fat cell to store excess calories

while increasing the proportion of energy that is frittered away as heat. More than a decade of focused and persistent research, almost swimming against tide, has brought about the reality that there exists a connection between dairy products consumption and weight loss. As early as in mid nineties, scientists at the University of Purdue reported that women between the ages 18 and 31 years when put on a diet rich in milk either lost unnecessary weight significantly or maintained their normal weight over a span of two years. In contrast others avoiding dairy products put on perceptible weight over the same period. Later dieticians at university of Tennessee following the growth pattern of children from infancy to school going age found that more calcium rich foods they ate, lesser was the body weight clearly confirming the theory that milk has an important role in controlling overweight, especially amongst youngsters. It came out that people eating a diet rich in milk or milk products were only one-sixth as likely to be obese as those whose diet provided little. Calcium rich foods in general were beneficial while calcium-poor diets tended to accumulate weight leading to obesity. Incorporation of milk even in low calorie diets aimed at weight reduction accentuated the weight-losing trend. The critical constituent in milk responsible for this phenomenon was thought to be calcium, which has a multiple role to play in human system. Besides its stellar role in bone formation and maintenance, calcium is also implicated in blood vessel dilation and message carrying function of nerves. Calcium is a critical signaling agent helping all sorts of cells figure out what they need to do. By far fat cells seem to be influenced more by calcium level in the blood. When there is plenty of calcium, fat cells get the message to quit storing fat and start burning it. At low calcium levels reverse seems to be happening and fat cells get bigger and bigger that manifests in large body size. Calcium pills are no substitute for the complex package of nutrients found in milk. The clear message is that if one wants to be on a weight-losing regime, exclusion of, or limiting the diet with regard to, milk and milk products can be a grave mistake. The old adage that “an apple a day keeps doctor away” may be more appropriate if the apple is substituted with “a glass of milk”.

Definitions and Legal Standards: All the persons engaged in dairying should always bear in mind that they are dealing with a food which is consumed by infants, growing children, the sick and the aged and accordingly follow high standards of safety and hygiene holding morality on the top. Foods being consumed by the society have to be safe and nutritious. Therefore, the standards for various foods have been defined under the Food Safety and Standards Act (FSSA), the Weights and Measures Act and Rules, AGMARK Grading, Bureau of Indian Standards (BIS) Specifications, etc. The definitions of milk and some milk products under the FSSA are as under:

Milk: Milk is the normal mammary secretion derived from complete milking of healthy milch animal without either addition there to or extraction therefrom. It shall be free from Colostrum. Milk of different classes and of different designations shall conform to the standards laid down in the Rules.

The standards for different classes namely Buffalo milk, Cow milk, Goat or Sheep milk, Mixed milk etc. are given in Table 2.2.

Table 2.2: FSSAI Standards for Different Classes of Milk

Class of milk	Designations	States & Union Territories	Minimum Percentage	
			Minimum Fat%	Minimum SNF
Buffalo Milk	Raw, pasteurised, boiled, flavoured and sterilized	Assam, Bihar, Chandigarh, Delhi, Gujarat, Maharashtra, Haryana, Meghalaya, Punjab, Sikkim, Uttar Pradesh, West Bengal, Andaman & Nicobar, Andhra Pradesh, Arunachal Pradesh, Dadra & Nagar Haveli, Goa, Daman & Diu, Kerala, Himachal Pradesh, Jammu & Kashmir, Karnataka.	6.0	9.0
	- do -	Kerala, Lakshadweep, Madhya Pradesh, Manipur, Mizoram, Nagaland, Orissa, Pondicherry, Raichan Tripura, Tamil Nadu.	5.0	9.0
Cow Milk	- do -	Chandigarh, Haryana, Punjab.	4.0	8.5
	- do -	Andaman & Nicobar, Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Dadra & Nagar Haveli, Delhi, Goa, Daman & Diu, Gujarat, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Lakshadweep, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Nagaland, Pondicherry, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttar Pradesh, West Bengal.	3.5	8.5
	- do -	Mizoram, Orissa.	3.0	8.5
Goat or Sheep Milk	- do -	Chandigarh, Haryana, Kerala, Madhya Pradesh, Maharashtra, Punjab, Uttar Pradesh.	3.5	9.0
	- do -	Andaman & Nicobar, Andhra Pradesh, Arunachal Pradesh, Assam, Bihar, Dadra & Nagar Haveli, Delhi, Goa, Daman & Diu, Gujarat, Himachal Pradesh, Jammu & Kashmir, Karnataka, Lakshadweep, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Pondicherry, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttar Pradesh, West Bengal.	3.0	9.0

Mixed Milk	- do -	All India	4.5	8.5
Standard ized Milk	Pasteurized flavoured and sterilized	All India	4.5	8.5
Recombi ned Milk	- do -	All India	3.0	8.5
Toned Milk	- do -	All India	3.0	8.5
Double Toned Milk	- do -	All India	1.5	9.0
Skimmed Milk	- do -	All India	Note More than 0.5	8.7
Full Cream Milk	Pasteurized and sterilized	All India	6.0	9.0

- **“Pasteurisation” / “Pasteurised”** means the process of heating every particle of milk to at least 63°C and holding at that temperature for at least 30 minutes or heating it to at least 71.5°C and holding for at least 15 seconds or an approved temperature time combination that will serve to give negative phosphatase test. The pasteurized milk shall be cooled immediately to a temperature of 10°C or less.
- **“Sterilisation”** means heating milk in sealed container continuously to a temperature of either 115°C for 15 minute or at least 130°C for one second or more in a continuous flow and then packed in aseptic condition in hermetically sealed containers to ensure preservation for at least 15 days.
- **“Boiled”** means milk which has been brought to boil.
- **“Flavoured”** means it (milk) may contain nuts (whole fragmented or ground), chocolate coffee or any edible flavour, edible food colour and cane sugar. It shall be pasteurized, sterilized or boiled.

Subject to the standards given in **Table No - 2.2**, the different classes of milk may be described as under:

- Buffalo milk and cow milk means the milks obtained from buffaloes and cows respectively.

Mixed milk means a combination of milk of cow, buffalo, sheep, goat or any other milch animal which is made and conforms to the standard given in Rules.

Standardised milk means cow milk or buffalo milk or sheep milk or goat milk or a combination of any of these milks that has been standardized to

fat and SNF percentages given in the Rules. It shall be pasteurized and shall show negative phosphatase test.

- Recombined milk means the homogenised product prepared from milk fat, non fat milk solids and water and it shall be pasteurised and show negative phosphatase test.
- Toned milk means admixture of cow or buffalo milk or both with fresh skimmed milk OR admixture of cow or buffalo milk or both with adjustment of milk solids so that the product is standardized to 3% fat and 8.5% SNF given in the Rules. It shall be pasteurised and shall show negative phosphatase test and when milk solids are used the product remains homogeneous and no deposition of solids takes place.
- Double Toned milk means the product as described above (Toned milk) except that it shall be standardised to 1.5% fat and 9% SNF.
- Skimmed milk means the product prepared from milk from which almost all the milk fat is mechanically removed and it does not exceed 0.5%.
- Full cream milk means milk or a combination of buffalo or cow milk or a product prepared by combining both with addition of milk solids and standardised to 6% fat and 9% SNF. It shall be pasteurized and shall show negative phosphatase test.

Milk Products

Milk is unique in its physico chemical properties in that its proteins are in colloidal suspension and dissolved form which can be coagulated; lactose in its dissolved form which can be fermented and fat is in emulsion which can be separated to desired level or allowed to impart smoothness. This makes milk an ideal food for its conversion into several products by applying proper techniques. Some of these products can be termed as intermediary like butter which can be further converted into ghee or some like khoa and channa which are used in combination with wheat flour, sugar and flavours to make final product like Gulabjaman and Rasmalai. These are few examples in Indian context whereas Cheese, Ice-cream and Chocolates can be cited as examples wherein literally hundreds of varieties have been developed in western countries. Some of these milk products are briefly defined/described below.

- **Cream:** Cream means a product of cow milk or buffalo milk or a combination thereof, which is free from any foreign ingredient. It may be low fat cream with fat not less than 25%, medium fat cream with fat not less than 40% or high fat cream with fat not less than 60% by weight. Cream without any indication shall mean high fat cream.

Cream is obtained by centrifuging milk at low temperature. It is the fat containing fraction which is separated during centrifuging and is collected from the sides of the centrifuge vessel. The centrifuge consists of a bowl with a large number of

conical discs arranged one over another. The other fraction obtained at the end of centrifuging which is depleted in fat content is called skimmed milk and generally contains 0.04 to 0.05% fat and is used in the manufacture of condensed milk, milk powder, butter milk and cheese. The yield of cream is about 10% from buffalo milk and 6% from cow milk. Aerated cream is produced by keeping the cream in contact with high pressure carbon dioxide and releasing the pressure when the cream swells to about 6 to 8 times its volume.

- **Butter:** Butter is exclusively derived from cow or buffalo milk or its products principally in the form of emulsion of water-in-oil. The product may be added with common salt or no salt and starter culture of harmless lactic acid bacteria. Table butter has to be obtained from pasteurized milk and/or milk products which have undergone adequate heat treatment to ensure microbial safety. Butter has to be free from any other animal body fat, vegetable oil and fat, mineral oil and added flavour. It may contain additives permitted under the FSSAI Rules. When butter is offered for sale without any indication the standards for table butter are applicable. Table Butter and Desi cooking Butter have to conform with the following requirement.

Product	Moisture	Milk Fat	Milk SNF	Common Salt
Table Butter	Not more than 16%	Not less than 80%	Not more than 1.5%	Not more than 3%
Desi Butter	-	Not less than 76%	-	-

Butter is homogeneous mix of milk fat and butter milk. It is a good source of vitamin A and vitamin D and is characterized by its high spreadability not found in any of its synthetic substitutes.

Butter is obtained from high acidity curd containing about 1% lactic acid by diluting the curd with equal amount of water and churning it. The high acidity curd is obtained by using higher proportions of starter and keeping the starter added milk in warm condition. The ageing period, however, should not exceed 24 hours before the churning operation is carried out.

Makkhan or desi butter is prepared by churning dahi after diluting it with water in earthen pots with a wooden pole. The Makkhan is collected at the sides of the pot and the pole and is skimmed off by hand. It is then converted into ghee by submerging it in water or butter milk for many days. Makkhan usually contains 18-25% water and varying proportions of curd. It is normally not salted.

- **Ghee:** Ghee means pure clarified fat derived only from milk or curd or from desi butter or cream to which no colouring matter or preservative is added. In ghee the maximum permissible percentage of Free Fatty Acids (as oleic acid) is 3 and that of moisture 0.5. It has also to conform to the range of Butyro refractometer reading and minimum Reichert value as specified for each state and region in the FSSAI Rules.

Ghee is next to milk in importance as a dairy product. It is obtained from butter by elimination of water. It is preferred to butter because of its property of not getting spoiled even after prolonged period of storage. The traditional process of making ghee consists of sour curdling the milk, recovering butter and heating the butter to eliminate water. The market value of ghee depends quite a lot on its appearance such as colour and grain structure. The cow ghee is yellow in colour while the buffalo ghee is white with a greenish tinge. The grains in buffalo ghee are bigger and harder than those in cow ghee. The flavour of ghee is also important for its market.

- **Malai:** when milk is heated on the top layer of milk a layer of fat and coagulated proteins is formed and is called malai. Slow heating helps in obtaining a thicker layer of malai although the layer thickness is also dependent upon the quality of milk. Buffalo milk gives a thicker layer of malai than cow milk due to its higher fat content. Its approximate composition is as follows:

Water 60-70%; Fat 25-30%; Proteins 3.0-3.5%; Lactose 3.3-3.8%; Ash 0.4-0.5%

- **Dahi:** Dahi is obtained from pasteurised or boiled milk by natural souring or otherwise, by harmless lactic acid or other bacterial culture. It may contain added cane sugar (mishti doi). Milk solids may also be used in preparation of dahi. It shall have minimum Fat and SNF percentages as per the class of milk (cow, buffalo, toned, etc.) from which it is prepared. If class of milk is not indicated then the standards of buffalo milk are applicable. Dahi is consumed as such or used in the preparation of butter. It is the Indian counterpart of Yogurt or cultured milk.

Dahi for direct consumption is prepared preferably from buffalo milk. The milk is first boiled and then cooled to 32°C. A starter (usually dahi of the previous day) is added to the extent of 1-5%.

The milk containing the starter is kept for ageing under warm conditions such as keeping near the kitchen fire or wrapping a cloth round the container. Dahi is ready for consumption in 10-12 hours. Sugar is added if a sweetened product is desired. Butter fat tends to concentrate on the top layer consisting of cream especially when the container is of a shallow pan type. For obtaining dahi of homogeneous fat content the milk must be stirred for 3 to 4 hours just after the addition of starter.

- **Lassi:** Lassi is a drink prepared by churning dahi with water in presence of some ice. Ice facilitates the separation of fat in globules during churning. Lassi is relished as a cooling beverage especially during hot weather and consumed with either spices and salt or sugar. Its approximate composition is as follows:

Water 90-91% ; Fat 0.1-1.0% ; Proteins 3.3-3.5% ; Lactose 2.5-3.5%; Ash 0.7% and Lactic acid 0.5-1.1%

- **Chhas/Chhach/Mattha:** It is buttermilk which is very popular as summer beverage. It is obtained during preparation of makkhan (Desi butter) from dahi / cold

water mixture. It may be flavoured with salt, crushed ginger, curry leaves and green chillies. It contains 6-7% milk solids and 1-2% fat.

- **Channa Podo:** Channa is a product obtained from cow milk. Milk solids may also be used in its preparation. Channa is largely used in Bengal for the preparation of Bengali sweetmeats like Rasgolla, Sandesh, Channa, Peda, Rajbhog, etc. It is prepared by coagulating hot cow milk with lactic or citric acid, soured whey or lime juice with vigorous stirring. The coagulum or Channa is separated by filtering through a filter cloth.
- **Paneer:** Paneer is a product obtained preferably from buffalo milk or mixture of buffalo and cow milk and also milk solids. It is prepared by coagulating milk with soured whey, lactic or citric acid or lime juice.

The coagulum is pressed and then the solid mass is cut into desirable sizes. As per FSSAI Rules the Channa or Paneer shall not contain more than 70 percent moisture and the fat content shall not be less than 50 percent of the dry matter. However, if the product is offered as low fat paneer or channa then the milk fat shall not be more than 15 percent of the dry matter and it shall be in sealed container and with proper label.

- **Chakka:** Chakka is produced by separating whey from dahi. The firmly set dahi is stirred and poured in a muslin cloth and kept hanging for 8-10 hrs to drain off whey. This way hundred kg milk gives about 65 kg Chakka. In the mechanized process either basket centrifuge or quark separator is used to separate whey.
- **Shrikhand:** is obtained from chakka or skimmed milk chakka to which milk fat is added. It may contain fruits, nuts in addition to sugar, cardamom, nutmeg, saffron etc. it shall not contain artificial colours and flavouring substances. The product has to conform to following specification:

Total Solids, % by wt	Not less than 58
Milk fat, on dry matter basis % by wt	Not less than 8.5
Milk protein, on dry matter basis % by wt	Not less than 9
Sugar on dry matter basis % by wt	Not more than 72.5
Acidity, as lactic acid % by wt.	Not more than 1.4

- **Kheer:** Kheer is prepared by concentrating milk by heating in an open shallow pan on direct fire to one-third or one-fourth of its volume. Rice is also generally incorporated and the product is consumed after sweetening it. During preparation the milk is agitated by stirring for homogeneous consistency of the mix. Cow milk with 4 percent fat or for still better quality of kheer, buffalo milk with 5 percent fat and 9.5 percent SNF may be used while adding 12 percent sugar and 5-6 percent rice. In south India Payasam is prepared which resembles kheer. It may contain rice, wheat, Bengal gram dal, beaten rice, vermicelli, sago and even mango or jackfruit in combination with concentrated milk and sugar.

- **Rabree:** The preparation of Rabree also involves heating of milk but during preparation the milk is not agitated and if possible the top layer of malai on milk is fanned to facilitate its formation. The malai on the top layer is cut into pieces and deposited on the sides of the shallow pan above the layer of milk for further concentrating. When the milk reaches the desired consistency, sugar is added and the flakes from the sides of the pan are scraped and mixed with milk. The final product may contain 20 percent fat and equal amount of sugar.
- **Khurchan:** It may be prepared by same method as Rabree. The flakes obtained from the sides are called Khurchan
- **Khoa:** Khoa also called Mawa or kava and known after varieties such as Pindi, Danedar and Dap; is a product obtained by rapid drying of cow or buffalo or sheep or goat milk or a combination thereof. Milk solids can also be used in its production and the final product shall not have less than 30 percent fat by weight and shall be free from starch, added sugar and colouring agent.

It is prepared by boiling milk with continuous mixing till a dough of solid contents of milk is formed. When mixed with sugar it is a direct sweetmeat. It is used as an ingredient for other sweetmeats also.

- **Peda:** Peda is the most popular milk based sweet in India. It is prepared by mixing khoa and sugar in the ratio of 3:1 and heated gently till the mixture become firm. Flavouring substances like saffron, cardamom are added and the contents are converted into balls of 20-25 gm size. Pedas from Mathura, Rajkot, Dharwad and Satara have typical characters.
- **Gulabjamun:** Gulabjaman is prepared by mixing khoa and maida (3:1 ratio) with little amount of baking powder and dividing the dough into balls or in the shape of cylindrical portions. These are fried in oil and then allowed to remain in sugar syrup solution wherein they swell to double the size. Rose water is used to impart flavour.
- **Burfi:** Burfi is a product prepared in small batches by mixing desirable type of khoa with sugar (30 percent by weight) and any of the substances like cashew nut or almond or pistachio or coconut or mango etc. All the contents are heated on a pan skillfully and poured in trays or moulds in a uniform layer.
- **Kalakand:** Kalakand is a product prepared by blending sugar with "danedar" variety of khoa. Typically it has a pleasant caramel flavour and granular texture. When prepared from buffalo milk with 6% fat and 9% SNF, it is boiled for 15 minutes and citric acid is added to give granular structure to the mass. The sugar is added in the proportion of 7 percent of the weight of milk.
- **Condensed Milk:** Condensed milk is prepared largely in American and European countries. In India there are only few companies manufacturing it. It is prepared by evaporating milk under vacuum at 55° - 57° C to the desired consistency. The product is homogenized to prevent the separation of fats, cooled and

fortified. Stabilizers like calcium chloride are used to 'prevent coagulation during sterilization. In India, condensed milk is used largely by armed forces during wars for preparing tea etc. In India other indigenous products such as Kheer, Rabree and Khurchan are prepared which have the same approximate composition as condensed milk.

- **Cheese:** Cheese is prepared from the curd obtained from whole or skimmed milk with or without added milk by coagulating the casein and further treatment of the separated curd by ripening fermentation and seasoning. The process of making cheddar cheese of hard texture as used in U.S.A., U.K., and Canada is as follows:

The milk is initially heated to 30°C and mixed with a starter. When the acidity reaches 0.18-0.2% the milk is coagulated by adding rennet @ 0.05% of the amount of milk taken. A small quantity of cheese colour is also added and the resulting curd is cut into small cubes to facilitate the whey to drain. The cubes are now raked and heated to 38°C for such time till they attain a firm consistency. Cheese contains about 1% lactic acid at this stage. The whey is now drained and the cubes are cheddared or matted together along the sides of the vat. The curd is cut into strips, milled and stirred with salt. The salt solution removes a part of water and protein and helps in matting of the curd. The salted curd is pressed to remove water and ripened and cured for a very long period.

- **Casein:** Casein is prepared from skimmed milk obtained after separating the cream, by souring it and forming the curd. The curd is separated by using hot water and it pressed and dried to get the final product. It is a yellowish powder used in the preparation of foods for infants and invalid. It is used in the manufacture of industrial adhesives, plastic products, paints, distempers, cosmetics, soaps etc.
- **Ice Cream:** Ice cream is a flavoured product of milk. Its essential ingredients are milk, cream, sugar, flavour ingredients, dried fruit, nuts, juices and edible colours. Condensed milk and dry milk powder are also used to increase the concentration of solids not fat. Gelatin, egg yolk, sodium alginate, gum tragacanth, karaya gum, starch and sodium carboxymethyl cellulose are used in ice cream to improve the body, texture and overrun, prevent the formation of large crystals of ice, improve resistance to rapid wetting and prevent shrinkage.

Indigenous ice cream preparations include Kulfi and Malai-ki-baraf and are made and sold in many towns and cities in India.

- **Kulfi:** Kulfi is a nut ice cream frozen in small containers of conical shape. Sweetened milk containing 20-25% added sugar is concentrated to about half its volume. Malai, crushed almonds, pistachio and flavouring materials such as vanilla and essence of rose are added after cooling.
- **Malai-Ki-Baraf:** Malai-Ki-Baraf is a frozen mix of sweetened milk and malai. It may be mixed with fruits, coloured and flavoured before freezing.

A variety of dried milk products are prepared by the total removal of water from whole milk, skimmed milk, butter milk and whey.

- **Milk Powder:** Milk powder is generally prepared by spray drying while other products are made by roller drying. Roller dried products are not as easily dispersed in water as spray dried products but are equally nutritious.
- **Malted Milk:** Malted milk is used widely as an infant food and food for invalid. Malted barley is washed along with wheat flour in warm water until the starch is converted to maltose and dextrin. The filtered extract is mixed with whole milk. Small quantities of common salt and sodium bicarbonate are added and the mixture is concentrated in vacuum and dried in drum or spray drier.

Skimmed milk, butter milk and whey are the by-products of dairy industry. Skimmed milk contains all the nutritive elements of milk except fat and fat soluble vitamins. Butter milk is used as a beverage. Dried butter-milk is used as animal feed and in bakery products. Whey contains greater part of albumin, lactose and mineral matter present in the milk and rich in riboflavin.

New Whey Products: Whey can be converted into a range of products *viz.* whey powder, whey protein concentrate, granulated high protein whey powders. These products can be used in infant foods, weaning foods, bakery products, confectionery products, dairy products, etc. Beverages and Soups are generally consumed by large number of people for the reasons of their refreshing, tasty and nutritious nature.

Special Dietary Products: Recently the most emphatic trend in the new product development has been in the area of special dietary products. Another significant development in the area of special dietary foods is the wide range of functional foods, which affect one or a limited number of functions in the body in a targeted way so as to have positive effects.

Vitaminised Milk/Mineralised Milk: Vitaminised Milk/ Mineralised Milk is milk to which one or more vitamins/minerals are added. Addition of vitamins/minerals to milk is called fortification and such milk is called as fortified milk. The vitamins may be added singly or, more commonly as multi vitamin preparations. Mineralised Milk is milk to which minerals are added such as Iron, etc.

Chapter 3

Establishing A Dairy Plant

The decision to start a dairy has to be crucial one. Considering the investment in terms of money, labour and time (no holidays!) etc, the returns have to be ensured and this largely depends on application of thought and mind before the decision is made. Following are some important factors which should be considered by the entrepreneur.

1. Milk Availability :

For any dairy to run successfully the supply of milk around the year is a must. This can be ensured by organizing direct procurement of milk in the designated area or indirectly by entering into annual contract with suitable parties (Individuals, Private / Cooperative Dairies.). Both these systems have merits and demerits as shown under:

Direct Milk Procurement

1. It takes several months / years to organize farmers / milk collection centres / **milk Routes**. Requires patience. Once organized entire available quantity has to be procured. You cannot say 'No' to the farmers. You may have to establish chilling facilities.
2. You have to check quality at village level and also at the dairy plant. Refusal on account of quality may become problematic, may not be possible at all.
3. You can decide milk prices payable during lean / flush season. Cost of milk collection, transport has to be borne round the year.
4. You have to make milk payment promptly-weekly.
5. You may have to organize Veterinary service, Artificial Insemination facility, Fodder Seed-Cattle Feed supply and even credit / supply of milch animals.

Indirect Procurement

1. Milk readily available. You may have 2-3 parties on contract for supply of milk in chilled condition. It may be possible to procure less quantity if your dairy cannot handle contracted quantity – may be with some penalty.
2. You can check quality at your dairy plant. Refusal to accept low quality is possible.
3. Milk price and overheads payable to the contracted party are negotiable depending on demand and supply situation.
4. Milk payment as per terms of contract.
5. These services are not your responsibility.

The entrepreneur should make right choice while organizing / arranging milk procurement and ensure adequate supply so as to meet the operational viability and the installed capacity of the dairy plant. Further, the milk supply may have to be stepped up as per the projected demand of market milk as well as production schedule of the milk products on year to year basis. It is necessary to keep in mind that for milk, there is

flush season when milk is available in plenty and the lean season when it is scarce. This largely depends on the calving season of buffaloes and cows commensurating to certain months. Generally speaking, September to March is considered as flush season and April to August as lean season. In the case of buffaloes the milk production drops severely in August almost one fifth – as compared to peak in November-December. This trend may slightly change depending upon the breeds of buffalos and cows and the management practices like supply of green and dry fodder, cattle feed etc. followed by the farmers. In some milk sheds the farmers may be very progressive whereas they may lack basic knowledge where lot of Dairy Extension is necessary.

When the dairy organizes its own milk procurement it should be ensured that milk is collected in villages, both in morning and evening and milk collection once-in a day should be avoided altogether for whatever may be the reason. Generally, to save on transportation, such an approach is thought about which leads to quality deterioration. Emphasis should be given on bringing milk to the chilling centre/dairy within 4½ hours from the time it is collected in villages. It is always better to operate milk collection routes with short distance and time and bring more milk from fewer collection centres. Nowadays there is trend to install Instant milk coolers at the village level wherein the milk is cooled to 8°C within 3 hours. Milk thus cooled can be brought to the dairy plant by insulated milk tanker once in a day. In traditional system the milk is collected in aluminium cans which should be properly cleaned and sterilized after every use.

While organising milk procurement in the designated area it is better to have a detailed survey made so as to know about the population of milch animals and their daily milk production, the level of animal husbandry practices, milk production, marketable surplus and prices payable, quality at source and logistics to work out cost of milk collection etc. If there are competitors, their entire mode of operation should be studied as far as possible. The entrepreneur may take professional help to organize the network of milk procurement.

2. Market:

Before establishing a dairy it is absolutely essential to ensure adequate market for milk and milk products and preferably for both. While the volume of milk market would give the required daily turn-over and meet the overheads – apart from bringing cash in flow; the marketing of milk products would give value addition. Further, it is better to have closer access to the main consumption centre so that the cost of distribution is minimised and milk is made available in early morning hours under ideally packaged and cold condition.

It is better that the marketing plan of the dairy is drawn after carrying out a factual survey of the market area. The survey should focus on the consumer profile as per monthly incomes, cultural background, family size, children, actual daily consumption of milk and its end products, purchase of milk products, perceptions regarding quality,

present source of milk and milk products and lacunae with regard to supply, price paid by them etc. It should also cover the institutions like hotels, restaurants, hostels, hospitals and canteens etc. This would help the entrepreneur to decide about the capacity of the dairy and its product mix. If any distant market or export market is to be tapped then the demand may be ascertained through reliable sources.

3. Capacity:

The actual survey of milk procurement area and/or the availability of milk on contractual basis coupled with the action plan for marketing of milk and milk products would help the entrepreneur to decide about the capacity of the dairy plant. It is very crucial to work out these details so as to avoid frustration at a later date. Further, it is better to keep adequate provision to increase the capacity by addition of certain equipment in future rather than creating huge capacity to start with. Generally a dairy plant is designed so as to be able to receive the maximum quantity of milk that could be procured in flush season. If that much milk is not marketed then the dairy should have facilities to convert the surplus into milk product like cream, butter, ghee, skim milk powder etc.

4. Location Requirements

Land :

The location of the dairy should be determined on factual basis and it is desirable to select a location at which large quantity of milk could be collected and dispatched. It should be close to the milk producing area in case of product manufacturing unit and if the liquid milk is the main product, it should be close to the consumers so that transportation cost can be reduced. The proximity to a town would be of advantage in terms of school and housing facilities for the employees. In contrast if the dairy is in remote area it would be very difficult to attract and retain competent persons on the job. The dairy needs sufficient space for constructing main building and its future expansion, parking etc. About 2 acres of land is sufficient for dairy handling 10,000 litres of milk per day. However the built-up area to total area ratio should be 1:3. The location should have proximity to road/rail facilities.

Water:

The water should be available in adequate quantity i.e., about 2 litres of water for every one litre of milk handled. Further it is necessary to subject the water samples to the chemical tests so as to know the mineral contents.

Power:

The dairy requires adequate and reliable electricity supply available on 24 hours basis. Normally a 3 phase supply is required for milk processing plants. The power requirement depends upon the load to be connected. A stand – by generator is often considered for

connecting the essential sections. About 30 litres of the milk is processed per unit (KWH) of Electricity and approximately 300 litres of milk processed per litre of Furnace oil.

Effluent Disposal:

There are no hazardous effluents generated from a milk processing plant. However, construction of effluent treatment plant is necessary for treating the effluent before discharging in the manner acceptable to the requirements of the Pollution Control Board and it is necessary to get clearance from them.

5. Technical Consultant

The appointment of a reputed and experienced dairy consultant at right stage is very important for the success of the dairy plant. Consultant should be involved right from the selection of the site upto successful commercial production. He should prepare detailed techno-commercial project report including survey mentioned above. The report should give capital cost, economics of the project and financial analysis.

6. Design of Dairy / Other Buildings

Services of a reputed architect are desirable for designing a dairy and other buildings. He should be provided with a list of all functions that the plant has to perform such as whether it would handle only liquid milk or milk products and also the flow of milk and milk products in logical sequence. Height of each room, arrangement for the drainage, weight of different machines while in working condition are important criteria to design ceiling walls and floors. Other buildings needed are Service block, Transformer room, Stores, Transport depot, Workshop, Laboratory, Workers toilet and cloak room, Canteen, Quarters for essential staff, compound wall etc. The design should be such so as to provide built in arrangements to carry out modifications in future for enhancing capacity by addition of equipment and the building should be insect-proof, rodent-proof and bird-proof. The following points are very important:

- The milk route within the dairy premises should be short so as to minimize the cost of pipeline and save the time / cost of cleaning.
- Single storey building is most suitable. The floor level of milk reception and dispatch, and all rooms connected with milk processing should be the same and above the ground level to a height suitable for vehicles.
- The refrigeration and boiler room should be together in the same building. Boiler should be closer to the place where steam is required and the refrigeration room should be near the process hall and cold store.
- The laboratory should have easy approach to process hall, reception and production section.
- The cold store and office building should face North-South direction.
- It is better to incorporate various features and facilities required for good manu-

facturing practices (GMP). Emphasis should be given on sanitation and hygiene at every stage rather than huge lavish structure.

The total covered area depends on the processes involved, products manufactured, quantity of milk handled and equipment chosen. About 4000 sq. ft. area is required for a dairy plant handling 10,000 litres of milk per day.

7. Plant and Machinery

The entrepreneur should invite quotations for the plant and machinery from reputed firms indicating milk handling quantity per hour, per day, type of milk, bulk or small packing, types of the products, type of packaging, cold store requirements, stand by equipments, number of spares etc. The equipment should be capable of producing acceptable quality products, competitively priced and provide guaranteed service in terms of years. While incorporating new equipment/advanced technologies the entrepreneur should look for alternatives and enquire from more sources. Whatever is absolutely essential should never be compromised. It would be better if costly equipment is added on a later date when the project becomes viable. Here is a word of caution with regards to second hand or refurbished equipment (often imported). Any such offer should be examined critically, through expert's opinion.

8. Capital

Broadly the capital cost includes the cost of land, development of land, fencing, internal roads, all buildings, plant and machinery, preliminary and preoperative expenses, working capital and margin money, etc. The cost of the project works out approximately Rs. 500 to Rs. 1000 per litre of milk handled for a mini dairy depending upon the product mix, machinery and location etc. It may be noted that judicious use of capital is important to ensure economic viability of the dairy plant. One should be prudent while investing and accordingly borrow the capital from financing agency.

One important requirement is the working capital for purchase of various consumables and most importantly purchase of milk which is often neglected. The entrepreneur should underline that for continuous and adequate flow of good quality milk, timely payment to the farmers is a must. At the same time the sale proceeds should be recovered in time from the market and no overdues are allowed to build. This is so much important that any neglect in this area would boomerang and create financial crisis.

9. Permission & Regulations

Under the (Food Safety and standards Act (FSSA), MMPO registration is required. The other compulsory standards under the FSSA and the Packaging of Commodities (Weights & Measures) Act are applicable. The standards laid down by Bureau of Indian Standards (BIS) and AGMARK are optional. Other than this the entrepreneur would require to obtain permission from local authorities to construct buildings and have

water and power supply met by concerned authority. Similarly the labour law would be applicable for factory, workers and employees would be covered under the PF, Gratuity and State Insurance. The establishment shall have to be registered under shops & establishment, Sales Tax and for holding stocks of fuel, oil etc. Various statutory permissions required for dairy project are given in Annexure IV.

10. Manpower

The total requirement of manpower would depend on the operations involved and the quantity of milk handled. For handling of 10,000 litres of milk per day the requirement of manpower would be approximately 25. For all identified areas, small sections / task force shall have to be set up. For milk procurement and marketing the supervisory staff shall have to be properly selected, trained and kept motivated. For electrical and refrigeration section competent persons shall have to be employed. For a large size dairy plant it is advisable that the Dairy Technologist and the Plant Engineer are appointed well ahead of the commissioning of the dairy.

11. Food Safety and Quality Assurance

The dairy plant once established will have to run while following food safety standards and implement quality assurance program. Whereas for achieving food safety, various provisions are required to be made while designing of a dairy plant, for adherence to standards the manpower shall have to be trained continuously. For quality assurance various procedures for processing and quality checks shall have to be documented which requires professional assistance from qualified persons in this field.

12. Execution

All the actions mentioned above shall have to be carried out in the most logical manner so that no action is oversighted and nothing gets delayed because something was not done at right time. This alone would help the entrepreneur to commission the project in time and help to avoid the over run of the project. The timely completion would start the financial returns apart from honouring the commitments and launching the product.

Chapter 4

Important Processes Used in a Dairy Plant

The dictionary meaning of the word “Process” is ‘A course of action’ or ‘Stages in manufacturing’ or ‘Handle or deal with’ or ‘To treat’. In relation to dairying, the term includes cooling, pasteurizing and bottling and it also refers to process of making Cheese, Butter; Condensed, Evaporated and Dried Milk. In this chapter several important processes are briefly described. The reader will find production-wise details in subsequent chapters.

Processes used in Milk Handling:

1. Cooling:

In this process the raw milk is cooled down as far as possible to 5°C to prevent the growth of microorganisms and retain its freshness. When milk is in cans it can be cooled by using a portable refrigeration unit fitted on a trolley whose cooling coil is immersed in the can. This method is generally used at farm level for small quantity of milk. In the case of large quantity of milk, Bulk milk coolers are used which are horizontal, semicircular or vertical cylindrical tanks of 500-5000 litres. capacity with innerjacket and outer insulated body. The inner jacket has provision for circulation of either chilled water or a Direct Expansion cooling coil from a mechanical refrigeration system. In this tank milk is directly poured or pumped through a balance tank and it is agitated to have uniform cooling to 4°C.

2. Chilling

In this process large quantity of milk (over 5000 litres) is cooled down to 4°C at the chilling centre while using a plate chiller. Depending upon the milk quantity the plate chiller is assembled with plates which are tightly held between the frames. The plates are such that the flow passage for milk is on one side and the cooling medium (chilled water) is on the other side. In other words, there is counter current flow between milk and chilled water through alternate plates. It helps in efficient transfer of heat from milk to cooling medium resulting in quick chilling. The chilled milk then flows from plate chiller to insulated storage tank and held at 4°C. A mechanical refrigeration system with Ice Bank Tank (IBT) ensures supply of chilled water to the plate chiller.

3. Filtration

To remove the visible particles and dirt the process of filtration (straining) is used. For this purpose filters / clarifiers are available for cold and warm milk. The process is

performed in an enclosed jacket so as to permit operation under pressure and the filtration is done by either in-line installation of a perforated stainless steel frame or external plate frame on which a cotton flannel cloth is attached. The lint side of the filter always faces the flow of milk. The cold milk filter is placed between raw milk dump tank's unloading pump and the chiller whereas warm milk filter (wherein separation of dirt is efficient) is installed in pasteurizer circuit.

4. Clarification

The application of centrifugal force to remove dirt and particles heavier than milk is called clarification. It removes udder cells, fine dirt, coagulated milk protein particles, calcium phosphate and other minerals. In this process, continuous removal of sludge during the operation is possible by a suitable design. Otherwise, the bowl has to be opened intermittently to remove the sludge.

5. Bactofugation

It is well known that the bacteriological load of milk produced in India is high and may range from 2 to 10 million per milliliter, depending upon the season. It includes both the dead and vegetative cells. Cleaning of such milks by any mechanical process will be of great help to the industry and such process is likely to improve the natural flavour of milk and also increase the shelf life of milk and milk products produced thereof. The process involves subjecting milk to high speed centrifuging at around 50-60°C to remove bacteria in milk. The process can be adopted selectively before or after pasteurization depending on the equipment. The process is reported to remove 70-80% of bacterial cells from milk depending on the initial load. Perhaps in the years to come as the consumer becomes more demanding, this type of machine is likely to find place in many of the dairy plants in the country.

6. Pasteurization

It is a process of heat treatment which results in destruction of pathogenic microorganisms without impairing the value of milk. Pasteurization, according to Bureau of Indian Standards is a process of heating milk at a specified temperature, holding milk continuously for a specified period in a standard and properly operated equipment and immediate cooling in the same equipment after heating. The most widely used equipment for this purpose is called pasteurizer wherein both heating and cooling operations are carried out in two sets of plates – (as described above under chilling) in which heat is exchanged between 1-chilled milk and hot water, followed by 2-heated milk and chilled water. Two methods of pasteurization are generally applied. One is Low Temperature Long Time (LTLT) method wherein milk is heated to 63°C and held for 30 minutes and immediately cooled to 5°C. This is used for batch operation. The other method commonly used is High Temperature Short Time (HTST) wherein milk is heated to 72°C and held for 15 seconds followed by immediate cooling to 4°C.

The HTST method also uses regeneration whereby raw cold milk flows on one side of the plate and it is heated by hot pasteurised milk which saves 90 percent heat and refrigeration load.

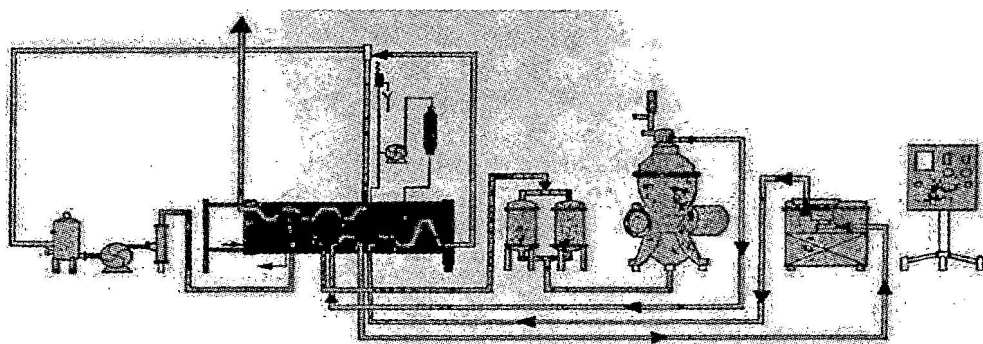


Fig. 4.1 Cream Separator in Circuit with Pasteurizer

7. Boiling

In dairy plants generally milk is not boiled because it leads to denaturation of milk proteins. However, the boiling process is applied in a hemispherical kettle to cream/butter during ghee manufacture. Boiler is used for steam raising.

8. Sterilisation

In this process milk is heated rapidly to a very high temperature to destroy all living cells / microorganisms. The term is also applied to a process of cleaning the equipment wherein practically most of the microorganisms are killed. e.g., steam – sterilization of milk cans.

9. Ultra High Temperature (UHT) Sterilisation

This process is used to preserve milk and other liquid food products by application of intense heat in the range of 135 to 146°C for a brief period of a flash of second or two. This destroys all microorganisms after which the product is cooled and packed aseptically so that there is no contamination afterwards. The packing material is generally a laminated paper which is converted in to the shape of a brick or a tetrahedron (pyramid) from which the name – Tetrapack was derived.

10. Separation

In this process the whole milk is subjected to the centrifugal force inside a cream separator wherein the fat rich portion is removed and obtained as cream and the heavier remainder as skim milk. Inside the cream separator the fat globules being lighter (sp.gr. 0.93) move towards the centre whereas the milk serum being heavier (sp.gr. 1.036) moves towards the periphery and both these fractions are collected through separate streams. The separation also occurs when milk is allowed to stand undisturbed.

11. Fortification

To increase the nutritive value of milk when vitamin is added it is called as fortification. Generally vitamin A in palmitate form is mixed in Toned or Double Toned milk so as to make up for the loss of vitamin A occurring due to the removal of Fat from the whole milk.

12. Standardization

In this process the fat and/or the solids-non fat (SNF) content of milk is raised or lowered so as to conform to the desired level in the end product. It is possible to do this in a single unit with tri-purpose centrifuge which separates, standardizes and clarifies the milk. If the incoming milk has lower fat content then a predetermined amount of skim milk is removed from the stream of the separator.

13. Reconstitution

In this process the milk is prepared by dispersing whole milk powder in water approximately in the proportion of one part of powder to 7 to 10 parts of water to produce whole milk or skim milk respectively.

14. Recombination

In this process the fresh milk is mixed with reconstituted milk and butteroil or white butter or cream for production of Standardized/Toned/Double Toned milk.

The process involves blending of SMP and water, melting and injecting butter oil / white butter followed by homogenisation and pasteurization.

15. Homogenization

In this process the fat globules in milk are reduced (microfined) in their size so that they get distributed throughout the body of milk. These globules which are in the size range of 0.1 to 20 microns are reduced to the size of 1 micron or less under mechanical pressure. Homogenized milk appears thicker and even in small quantity it gives more whitening effect to the tea or coffee. It is also ideal for uniform curd setting and yields cream with higher viscosity which is good for ice cream mix.

16. Agitation

In this process the milk is continuously stirred by a rotating fan attached to a motor fitted on the inside roof of the storage tank. This helps to achieve uniform temperature and prevents separation of fat and other solids and maintains homogenous distribution of all constituents.

17. Bottling

The bottling process was used for packing of market milk in good old days and the system is considered to be outdated. However, milk bottles are still used for packing flavoured milk and long life (sterilized) milk by many dairies. In this process the sterilized

product is filled in clean bottles and after their capping the bottles are further sterilized using high pressure and temperature.

18. Form-Fill-Seal (FFS) Packing

This is used extensively for packing of market milk and also various milk products in liquid form. In this process the plastic / aluminium foil coated board is formed into a pouch and hermetically sealed. The sealed package has horizontal and vertical seal.

19. Cleaning-In-Place (CIP)

This process is usually applied to the entire milk handling system viz., milk silos, tanks, pipelines etc., without dismantling them. The washing solutions are circulated in a programmed manner so as to achieve the level of sanitization which is counter checked by laboratory procedures.

20. Sanitization

It is usually applied to the inner side of equipment like milk silos, tanks, pipelines their bends etc., so as to maintain proper hygiene. This is done by use of proper methods and chemicals, etc.

Process used in Manufacture of Milk Products

In addition to the processes mentioned above following processes are used for milk products.

1. Fermentation

In this process the heat treated milk is cooled to 37°C and inoculated with a starter culture of *Lactococcus lactis*, *L. cremoris*, *L. diacetylactis*, *Lactobacillus bulgaricus* and *Lactobacillus thermophilus*. These bacteria multiply in milk and produce acidity. The process is carried out in a insulated vat to produce Dahi, Lassi, Chakka (for making Shrikhand) and also for Yoghurt. The inoculated milk is also packed and stored at ideal temperature for daily supply of curd to the market.

2. Ripening

In this process the cream is fermented by using bacterial cultures mentioned above. The term 'ripening' is also applied to cheese held for such time and at such temperature, and under such other conditions so as to result in necessary biochemical and physical changes of a particular variety of cheese.

3. Incubation

In this process the milk inoculated with bacterial culture is held at a fixed temperature for a fixed period. This allows formation of desired body, texture and aroma to the fermented product.

4. Churning

In this process the cream is subjected to violent agitation and beating in a cylindrical Butter Churn (Vessel) which is rotated on a horizontal axis. The churn has shelves attached to inside.

5. Whipping

In this process the cream is beaten so as to produce froth or foam. This is used in cakes and Ice cream.

6. Prestratification

In this process of making ghee the desi butter is heated to 80°C in a vat and held for 30 minutes. At that point it separates into three layers. The upper layer is taken to Gravity Separator and part to the Balance Tank. The Gravity Separator separates the butter into one fat rich component and other butter milk. The butter milk comes out of Gravity Separator. The fat rich portion is boiled further for precipitation of curd (as residue) leaving good quality ghee.

7. Coagulation

In the process of coagulation the heat treated milk is taken in a vessel and clotted by using required quantity of coagulant. The coagulant may be an enzyme, whey from the previous batch or acid like citric acid, lactic acid, or vinegar, lime or lemon juice which is added when the milk is held at 80 – 85°C.

This process yields chenna / paneer.

8. Ultrafiltration (UF)

This process is also referred to as Reverse Osmosis or Membrane Processing. This is a process of separation using synthetic membranes with extremely fine pores (1-20 nanometers) through which molecules of water and dissolved salts are forced out under pressure which results into retention of proteins and fat called as concentrate. This process is applied to concentrate milk and for recovering whey proteins.

9. Condensing

In this process the water in milk is evaporated partly or fully. Condensed whole milk and condensed skim milk are produced by removal of water under vacuum and identified after the solid content for example 40% condensed milk. The condensed milk may be further sweetened by addition of sugar which also acts as preservative.

10. Evaporation

In this process the preheated milk of acceptable quality (acidity between 0.18 - 0.22%) is continuously evaporated so as to remove the moisture to a desired level followed by immediate homogenization so as to obtain uniform fat emulsion and reduce its separation.

11. Drying

This process is also called as desiccation or dehydration in which water content is removed from a substance by heat or other means for its preservation. Milk is dried this way by application of heat to produce powder containing less than 3% moisture.

12. Roller Drying

In this process milk is dried by passing it in the form of a thin film upon the smooth surface of a rotating steam-heated metal drum. The milk dried this way is scrapped by a stationary blade and converted into powder by grinding.

13. Spray Drying

In this process the whole milk or condensed or skim milk is converted into powder by spraying it through nozzle into mist-like droplets from the top of a chamber in which hot air is blown in.

14. Instantization

This is a process by which dried milk, milk products are made instantly soluble by rehydration. The efficiency of instantization is judged by solubility index.

15. Modifying

In this process the composition of milk is modified so as to meet the desired composition. By reducing the fat and protein and increasing the lactose content milk is modified as humanized milk. Also, by lowering the lactose content by adding the enzyme-lactase-milk is modified to cater to the lactose intolerant people.

16. Stabilizing

Milk/Cream with developed acidity have a tendency to coagulate during heating. This is prevented by addition of stabilizers like bicarbonate, carbonate, phosphate etc. (approved under the FSSA) before heating. They keep the milk / cream stable. In the case of Ice cream the stabilizers are used to produce smoothness in body and texture, retard or reduce ice crystal growth during storage, provide uniformity of product and resistance to melting.

17. Emulsifying

In the process of emulsifying the fat in milk is uniformly distributed. In the case of Ice-cream it improves the whipping (foaming) quality of the mix, the production of smooth texture, thus giving a dry stiff product. Emulsifiers used in dairy products have been specified under the FSSA.

18. Ice-Cream Mix Processing

This is very important in the manufacture of Ice cream. It involves assembling the ingredients from the storage area to the mix preparation area, weighing or measuring

and mixing the ingredients and the pasteurization, homogenization cooling and storage of the mix.

19. Aging

This process has been practiced in the manufacture of ice-cream since its inception. During this process the Ice-cream mix is allowed to stand in aging vat when the fat gets solidified, if gelatin is added it gets swollen and it combines with water, the protein is changed slightly and the viscosity is greatly increased.

20. Cheese Processing

The basic process of cheese making which is common to most of the varieties of cheese involves Acidification, Coagulation, Dehydration / and Curd drainage, haping (moulding and pressing), and Salting / Brining.

21. Vacuum Packaging

In this process the air in a package is removed with no gas replacement resulting in skin tight packaging. This process delays the microbial deterioration and extends shelflife at refrigeration temp. e.g., Paneer.

22. Modified Atmosphere Packaging

In this process the normal air in a package is replaced by a gas or mixture of gases like carbon dioxide, nitrogen, oxygen, water vapour etc., depending upon specific requirement of a product. This process delays microbial deterioration. In the case of dairy products, when oxygen is removed, the oxidation of fat and development of rancid smell are prevented e.g., cheese and peda are packed in this way while replacing air with 80% nitrogen and 20% carbon dioxide. Whole milk powder is packed by flushing out the air and replacing it with nitrogen in the tins.

23. Automation

It is possible to control several operations in a dairy plant through automation. In the process, various actions needed for operating a process are ordered on the basis of instructions that have been fed to a micro-processor controlled programme.

The various process mentioned above and alike are carried out in a modern dairy plant while using dairy equipment like Pasteurizer, Storage Tank, Spray Drier etc., and dairy machinery that supplies electricity, steam, hot water, hot air, cold water, air conditioning etc. The equipment and machinery are logically installed to have a proper flow of the process and services. The reader will find the product-wise details in subsequent chapters.

Chapter 5

Equipment Required in a Market Milk and Dairy Product Plants

A wide variety of dairy and service equipment is available in various sizes and shapes and the dairy entrepreneur is likely to be puzzled while selecting them. However, by visiting any dairy we would find that certain types of equipment are common practically in all dairy plants. More important than installing various equipment is to maintain them in proper working condition. A breakdown somewhere may cause delay and sometimes paralyse the operation as many equipment are dependent upon each other for continuous plant operation.

Following is the list of various dairy and services equipment as per the plant capacity.

A. Small Size Market Milk Plant (10,000 Litres per day)

Milk Reception

Milk Cans (40 lit cap.)	400 Nos.
Can tipping bar	
Milk weighing scale (Electronic)	500 kg cap.
Stainless Steel Tank	1000 lit. cap.
In line strainer	
Milk Pump	5000 lit/hr.
Tanker unloading hose pipe	
Tanker unloading Pump	10000 lit/hr.
Milk Chiller	5000 lit/hr.
Milk can scrubber	
Raw milk storage tank	10,000 lit. cap.

Milk Processing

Milk Transfer Pump	3000 lit/hr.
Milk Pasteurizer	2000 lit/hr.

Cream Separator	2000 lit/hr.
High Pressure Homogeniser	2000 Lit/hr.
Milk Storage Tank	10,000 lit.
SS Pipes and Fittings	
CIP Equipment	
Milk Packing	
Milk transfer Pump	5000 lit/hr.
Balance tank with Float	100 lit cap.
FFS Milk Packing Machine	5000 Pouches/hr.
Crate Washing Trough	
Plastic Crates (10 lit cap)	1000 Nos.
Byproduct Making	
Cream Chiller	(Optional)
Cream Strong Tank	(Optional)
Butter Churn	500 lit cap.
Butter Trolley	
Ghee Boiler	200 kg cap
Ghee Balance Tank	100 lit.
Ghee Settling Tank	300 lit
Ghee Pouch Filling Machine	
Service Equipment	
Steam Boiler	500 kg/hr
Cold Storage & Refrigeration	
Electricals & LT Pannel.	
Water Supply, Tube Well	

B. Medium Size Market Milk Plant (50,000 Litres per day)

This will require all the equipment mentioned above with following changes / additions

Milk Reception:

Milk Cans	2000 Nos.
Milk Chiller	10000 lit/hr.
Raw Milk Storage Tank	15000 lit. cap. 2 No.

Milk Processing

Processed Milk Storage Tank	15000 lit cap. 2 No.
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Milk Packing

Milk Transfer Pump	10000 lit/hr.
Balance Tank with Float	500 lit 3 Nos.
FFS Milk Packing Machine	3 Nos.
Plastic Crates	2500 Nos.

Milk Products Section

Cream Chiller / Pasteurizer	
Cream Storage Tank	3000 lit cap
Cream Transfer Pump	
Butter Churn	2000 lit. cap
Butter Trolley	500 lit, 2 Nos
Ghee Boiler	500 kg cap.
Ghee Settling Tank	500 lit.
Ghee Storage Tank	3000 lit.
Ghee Clarifier	500 lit./hr.
Ghee Pump	
Ghee Pouch Filling Machine	800 pouches / hr.

Service Equipment

Steam Boiler	1000 kg./hr.
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C. Large Size Dairy Plant (Market Milk & Milk Products - 100000 Litres per day & above)

This will require all the equipment mentioned under A above with following changes / additions

Milk Reception:

Milk Cans	4000 Nos. and above
Raw Milk Storage Tank	30000 litre cap. 2 Nos. and more
Milk Chiller (30°to 4°C)	10000 litre/hr.
Milk Chiller (12°to 4°C)	10000 litre/hr.

Milk Processing

Milk Transfer Pump	10000 lit/hr.
Milk Pasteurizer	10000 lit/hr.
Cream Separator	10000 lit/hr.
Pasteurized Milk Storage Tank	3000 lit. cap. 2 Nos. and above
Pasteurized Milk Storage Tank	10000 lit cap. 2 Nos. and above
CIP	2000 lit.

Milk Packing

Milk Transfer Pump	10000 lit/hr.
Balance Tank with Float	500 lit 3 Nos and above
FFS Milk Packing Machine	5000 Pouches/hr. 3 Nos and above
Crate Washer	1000crates/hr
Plastic Crates	3000 and above

Service Equipment

Steam Boiler	5000 kg./hr
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D. Product Dairy Plant or Composite Milk Plant

Apart from all the equipment listed for market milk plant, the product dairy plant requires additional equipment as per the product mix chosen for the plant. Generally, the product wise equipment will be as under:

Market Milk: All equipment as mentioned above.

Butter: Butter Churn, Butter Packing Machine, Cream Ripening Vat, Vacuum Pasteurizer, Butter cold Storage (-19°C).

Ghee: Ghee Boiler, Strainer, Ghee Filling and Canning (15 kg Tins).

Casein: Casein Vat, Hoops, Press, Mill, Drier, Grinder, Sieves, Bag Stitching Machine.

Dahi & Chhas: Curd Tank, Chhas Tank, Chiller pump, Cup Filling Machine, Pouch Filling Machine.

Paneer: Paneer Vat, Paneer Press, Cooling Vat, Cutter, Pouch Sealing Machine.

Sterilised/Flavoured milk: Milk Tank, Syrup Tank, Bottle Filler, BottleCapper, Bottle Sterilizer, Plastic Crates, Glass Bottles.

Cheese: Cheese Vats, Starter making equipment, Cheese Mill, Cheese Press, Hoops, Knives, Shovels, Paraffining Vat, Cheese Curing Room with Racks.

Processed Cheese: Scrapper, Knives, Shredder, Processing (cooking) Kettle, Filling and Packing Machine.

Khoa: Khoa Making Equipment with Evaporator and Khoa Pans.

Condensed/Sweetened Condensed/Evaporated Milk: Forewarmer, Super Heater, Sugar Mixer, Vacuum Pan, Drop Tank, Homogenizer, High Pressure Pump, Cooler, Forced Crystalization Tank, Filling & Packing Machine, Sterilizer.

Spray-dried Milk: Condensed Milk Storage Tank, Pre-Heater, High Pressure Pump, Atomizer, Drying Chamber, Air Heater, Powder Collector, Cyclone, Filling & Packing Machine

Ice Cream: Storage Tank for Mix, Batch Pasteurizer, Homogenizer, Ageing Vat, Ice cream Freezer, Accessories, Ice cream Hardening Room

Laboratory Equipment: The importance of Quality Assurance rather than quality control in a dairy plant need not be over emphasized. The success of dairy plant and its products would absolutely depend on how best the quality products are sent to market. This requires proper planning of a laboratory to carry out routine checks at various stages in processing and production. Accordingly the necessary laboratory equipment shall have to be incorporated while designing a laboratory. As per the size of operation and the range of milk products the list of equipment would vary. The entrepreneur should look at this equipment as an investment for a better future. **The standard list of laboratory equipment is given in Annexure - V.**

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Chapter 6

Market Milk and Other Milks

Typically a Market milk plant is designed with the main objective of supplying processed and packed milk to the market on daily basis. It is possible to use this facility to produce chocolate drinks, sterilizer milk, milk orange and soy milk etc., in bottles/pouches and distribute them along with market milk. The working in market milk plant is subdivided as under:

Milk Reception : The plant receives fresh milk in cans or chilled milk brought in tankers. After organoleptic tests (smell, taste), the milk weightment is recorded as per the source (collection centre / society / agency) and type of milk (cow / buffalo). The samples are drawn and sent to laboratory for chemical analysis. The accepted quantity is chilled and stored whereas milk with smell / acidity is diverted for separation. The empty cans and tanker are cleaned and returned.

Milk Processing: The chilled milk is pasteurized and stored till it is packed. Depending on product mix the milk may be separated, reconstituted, standardized or homogenized to produce milk of desirable grade in terms of fat and SNF.

Milk Packaging: The Market milk is packed in 500 ml or 1 litre pouches on automatic Form-Fill-Seal machines. The pouches are arranged in plastic crates holding 10 litres each and passed on roller conveyer to the cold room.

Storage: In cold room the plastic crates holding milk are stacked in layers and held for several hours before dispatch. The empty crates returned from the market are cleaned and stored for next shift.

Services: The market milk plant is equipped with Steam boiler, Refrigeration and cold storage, Electrical substation, Diesel generator set, Water softening plant, Water supply and Effluent treatment plant.

Market Milk

Processing: It is of paramount importance to maintain efficiency and uniformity of various components of this activity so as to ensure customer satisfaction.

The schematic flow diagram for market milk is given in figure 6.1.

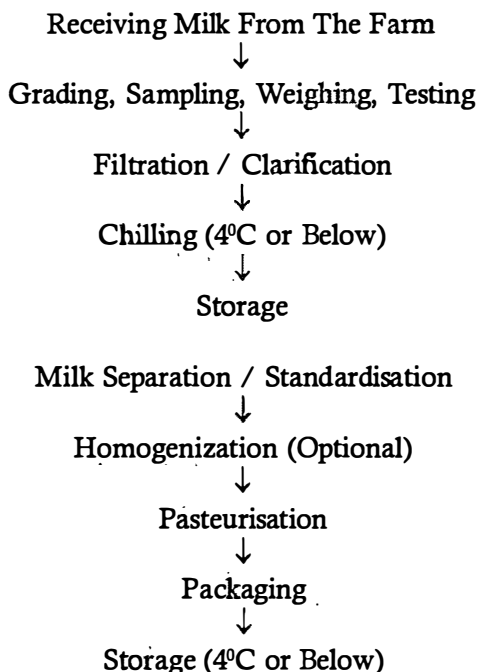


Fig. 6.1: Flow Diagram for Market Milk

The Equipment Layout for Composite Dairy is given in Annexure VI.

Chilling: On acceptance of quality, the milk should be checked for its temperature and subsequently chilled if it records more than 5°C. In case pasteurised milk is received at the temperature up to 7°C, it is taken for processing straightway.

Storage: While Loading / Unloading milk, the agitator in tank (Silo) should be always in motion. It should be ensured that the milk is always stored at the temperature below 5°C. Further, it is not to be stored continuously over 20 hours so as to facilitate washing of silo once after every 20 hours.

Separation: After filtering the milk on line, the separation should be carried out at the temperature of 45° to 50°C in a cream separator with variable fat percentage desired in the skim milk and the cream.

Standardization: This should be carried out at 40° to 45°C by addition of skim milk powder, cream, skim milk, whole milk according to availability and requirement of the market milk standard. This process may be manual or through equipment (ventury) but at the end of it, the sample of milk should be checked for desired content of fat and SNF.

Homoginisation: This should be carried out at the temperature of 60°C and minimum 1900 psi pressure maintained at single stage for market milk. The degree of

homogenization is measured either by microscope or by Gerber test for top and bottom layers of milk kept at the temperature of 5°C for 48 hrs undisturbed. The percentage difference between fat % of top layer and that of bottom layer divided by the fat% of the top layer shall be the homogenization index.

Pasteurization: The market milk should be pasteurized in HTST pasteurizer at the heating temperature of minimum 80°C and maximum of 83°C for a period of 16 seconds while ensuring that the milk flow through the holding tube for a minimum period of 20 seconds followed by cooling the milk to a temperature of 5°C or less. The media required for heating the milk should be 1.2 times more than the milk flow rate to be confirmed by the reading of 2 kg psi in the pressure gauge and by keeping suitable water pump.

Reconstitution: This should be done by using potable water of less than 10 ppm TDS.

Production: The dairy may produce any of the market milks as per market demand. Often a suitable advertisement campaign is required to educate the customers about certain type of milk. The following types are mentioned under the FSSA.

Skim Milk: This is produced either by separation of cow milk or by reconstitution from skim milk powder and standardized to not more than 0.5% fat and not less than 9% SNF in the skim milk. During standardization vitamin A Acetate of 1.0 m IU/gm is added in proportion of 2.1 ml per 1000 litres of skim milk. This should be homogenized and the final product should have white colour, good flavour and acidity not more than 0.14% Lactic acid, with MBR test of not less than 5 hours 30 minutes with ambient temp shelf life of not less than 12 hours.

Double Tonned/Tonned Milk: This is produced by any of the following methods:

- i. From cow milk in combination with skim milk or reconstituted skim milk (Produced from BIS grade Skim Milk Powder),
- ii. From fresh sweet cream with not more than 0.14% acidity in combination with skim milk or reconstituted skim milk (produced from Skim Milk Powder)

During the process of standardization, Vitamin A concentrate IP (INDOFARIN-A 1.0 Oily) should be added in proportion of 1 ml per 1000 litres of milk and the milk should be homogenized. As per FSSA, the Double Tonned milk shall have not less than 1.5% fat and not less than 8.5% SNF whereas Tonned milk shall have not less than 3% fat and not less than 8.5% SNF. The norms for colour, flavour, acidity, and shelf life should be the same as mentioned under skim milk.

Note: The addition of vitamin A (fortification) is optional.

Standardized Milk: This is produced by using Buffalo milk/cow milk and standardized by using fresh sweet cream of cow/buffalo milk in respect of the type of milk used and reconstituted milk (produced from Skim Milk Powder). The standardized milk prepared this way shall have not less than 4.5% fat and not less than 8.5% SNF. The

homogenization of this product may be done to the extent it is necessary in view of the cream used. The norms for colour, flavour, acidity and shelf life should be the same as mentioned under skim milk.

Cow Milk: The cow milk can be processed and supplied as such. However, it should have not less than 3.5% fat and not less than 8.5% SNF. This milk may, or may not be, homogenized. A certain market may expect yellowish cow milk as genuine. Whereas, homogenized cow milk may also attract consumers for its white appearance and apparent thickness. The norms for flavour, acidity and shelf life should be the same as mentioned under skim milk.

Whole (Buffalo) Milk: The whole milk is actually Buffalo milk with not less than 5% fat and not less than 9% SNF. This should be processed and supplied as such. This milk should not be homogenized – If done it is likely to have adverse reaction from the customers, since it is expected to yield cream during household use. The norms for colour, flavour, acidity and shelf life should be the same as mentioned under skim milk.

Packaging: Nowadays all the market milks are being packed in plastic (polyethylene) pouches. Whereas bulk supply to the canteens, hostels, hospitals, hotels etc., is carried out in aluminium or SS milk cans. The entrepreneur should select proper quality of polyethylene film so that the problem like leaky pouches etc., can be avoided which are often due to lower quality of the polyfilm. The good quantity polyfilm is one which is produced from 50% Reclair 0-19010 and 50% LDPE. The thickness of the polyfilm should be 60 microns with allowance of minus 5 microns. The artwork and design over the polyfilm should be spaced in such a way that adequate space is provided to facilitate horizontal and vertical sealing on the surfaces without ink. Further, while printing the polyfilm all the legal requirements should be fulfilled, viz., Name, Address and MMPO Regn. No. of the Dairy, Type of milk whether Skim / Double Tonned / Tonned / Cow / Standardized / Whole milk; Content – whether 1 litre or 500ml, Fat percentage and SNF percentage as per the type of milk, Pasteurized / Homogenized, Maximum Retail Price, whether fortified with vitamin A, and Date of Packing. Apart from this the entrepreneur may also mention the names of other products or even provide space for small advertisement (optional). The 1 litre pouch should measure 22.3 cm in length and 14.8 cm in width whereas 500 ml pouch should measure 14.8 cm in length and 14.8 cm. in width.

Storage: It is absolutely necessary that the packed milk at the time of removal from the cold storage should have temperature of not more than 4°C. To achieve this, the ideal temperature of the cold storage in the beginning of the loading should be -5°C. The packed milk should be held in the cold storage for a minimum of 4 hours.

The plastic crates used for dispatch of milk should be of uniform colour and manufactured from 80% HDPE and 20% PPCP with the dairy's name embossed on it. From packing line these crates should be carried on trolley to the cold storage and

stacked at proper place for removal on first in first out basis. The stacks should be arranged in a descending order so that on the side of delivery door the stacking will have more height and this will taper towards the cold room blower. Further, there should be a distance of 1 foot between stacks and the wall and a clear space of 3 feet between the top crate and the ceiling. Between the rows of stacks there should be a distance of 2 inches. All this arrangement would ensure proper circulation of cold air and give desired temperature.

The market milk thus stored, should be transported to the market preferably in insulated vehicles which should be cleaned regularly and also sanitized frequently.

Chocolate Milk & Drink

Chocolate milk and chocolate drink rate high with consumers. Whole milk, skim milk or a mixture of the two may be used in making these drinks.

The drinks consist of milk or skim milk, sugar, cocoa or chocolate, a suspending agent, vanilla and salt. A desirable chocolate milk is one that has a milk chocolate flavour, little or no sediment, no ragged dark coloured cream layer, a low to medium colour and medium to high sweetness.

For making a chocolate milk drink, the following formula may serve as typical:

Cocoa	1 to 1.5%
Sugar	5 to 7.0%
Stabilizer	0.2%
Butter Fat	2.0%
Vanila flavoring and salt	to taste

Production: The cocoa, sugar and stabilizer are mixed thoroughly. This dry mixture is added with constant agitation to a vat of milk heated to 71°C or to a temperature recommended by the stabilizer manufacturer. The resulting product is held at 71°C for 30 minutes while being agitated constantly, then cooled to 4°C over a surface cooler and bottled. By holding at 71°C for 30 minutes the creaming property of the milk is nearly destroyed. It is usually wise to homogenize the milk (if using a milk that contains fat) before the mixture is added. This will assure the destruction of any cream layer that might form in the filled bottle. If Irish Moss is used as stabilizer, the milk should not be homogenized because the net result will be destruction of the stabilizing property, and setting will result.

Milk Orange Juice: With the recent advances in processing technology, it is now possible to make a new, refreshing and nutritious beverage a stabilized combination of milk and orange juice.

The product combines the highly desirable protein and mineral constituents of milk with the vitamins and other nutrients of orange juice. These constituents are retained in the combination and manufacturing process. Fortification with vitamins A and D

can be carried out with no effect on the drinking characteristics of the beverage. Its consumption should improve the diets of those who are deficient in calcium and certain vitamin and amino acids.

The following formulation is used:

Ingredients	% by weight
Whole milk (3.25% fat)	56.8
Orange Juice (11.8 Brix)	38.0
Sugar	5.0
Stabilizer (CMC)	0.2
	100.0

Add 7 gm. of single strength orange oil, per 100 kg.

Processing: The equipment needed are raw milk storage tank, orange juice tank, mixing tank, funnel with recycling pump, HTST pasteurizer, homogenizer and finished product storage tank.

Production: Measured quantity of milk, cooled to less than 4°C is poured into the mixing tank. Sugar and stabilizer mixture (10:1) is then added through the funnel while the liquid is being recycled and agitator is on. The return line must be below the milk level in the mixing tank to reduce foaming. Recycling pump is turned off as soon as all of the stabilizer-sugar mixture has been incorporated. The mixture is then aged for at least 15 minutes at less than 4°C cold orange juice (11.8 Brix or fresh) is then added to the milk-stabilizer mixture. The orange juice should be added below the surface of the milk to minimize foaming. Remainder of the sugar is then added and mixture is allowed to age for at least 15 minutes at less than 4°C. The mixture is pasteurized at 73°C (HTST) and homogenized after the holding tube at 3000 psi (first stage) and 500 psi (second stage). After homogenization the mix is cooled to <4°C and packaged. The product has a shelf life equal to or better than homogenized milk of the same quality raw milk.

Sterilized Milk

The sterilized milk is homogenized milk which has been subjected to heat treatment for such time as would ensure that it can be expected to remain fit for human consumption for at least seven days and which is contained in a bottle (being the bottle in which it has been heat treated) sealed with a vacuum seal. At least two, possibly three factors must contribute to the success of sterilized milk and these are:

- i. Little or no home refrigeration thus sterilized milk becomes handy as fresh sweet milk to prepare beverage etc.,
- ii. Use of satisfactory container that will preserve freshness and offers certain economic advantage over hermetically sealed cans, and
- iii. Lack of potable water hence making reconstitution from milk powder for beverage.

age purpose makes it an unsafe production.

Production:

After a preheating stage to 80°C in bulk, milk is bottled in a conventional filler. After sealing, the bottles are sterilized on a datum of 110/115°C for 30 minutes. This process often gives a strong cooked flavour and brown colour to the end product. Therefore, it is advisable to produce only small batches.

The other method is called Two-stage sterilization. In this, the milk in bulk is first heat treated at high temperature (the highest possible for the stability of milk). It is then filled in plastic or glass bottles in a conventional environment and finally in sterilized bottle. According to the quality of the raw milk, it is easy to adjust parameters of this process. The best quality product is obtained only if the first treatment is by ultra high temperature (UHT Method). The Flow Diagram for the Manufacture of Sterilised Flavoured Milk is given in Figure 6.2.

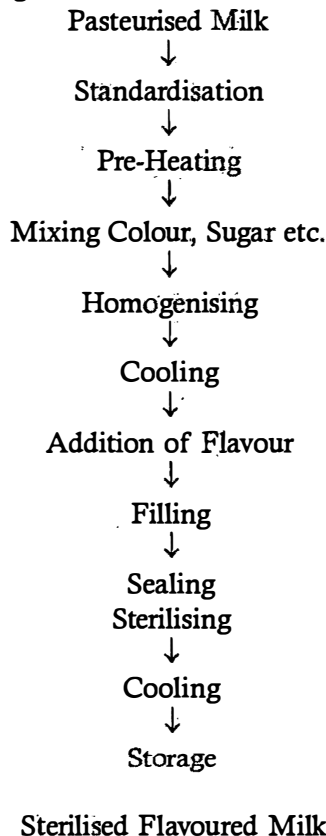


Fig. 6.2: Flow Diagram for the Manufacture of Sterilised Flavoured Milk

Filled & Imitation Milk

These are becoming popular in the West mainly because of low calorific value compared to whole milk and also because of low Cholesterol content in the absence of milk fat (butter). Vegetable fats, which are usually lower or devoid of cholesterol, are generally used to replace the butterfat. To disperse the vegetable fat it becomes necessary to add emulsifier / stabilizer in the absence of natural milk phospholipids prior to homogenization. Imitation milk can be made by recombining individual components.

Production:

Filled and imitation milks can be prepared by using the following ingredients.

Filled Milk		Imitation Milk	
Ingredients	%	Ingredients	%
Water	86.00	Water	86.30
SNF	10.00	Lactose	6.60
Fat (vegetable)	3.50	Sodium Caseinate	1.00
Emulsifier	0.20	Corn Syrup Solids 24 D.E.	2.00
Carrageenan	0.30	Fat (vegetable)	3.50
		Sorbitan Monostearate	0.30
		Sodium Alginate	0.30
	100.00		100.00

The flow diagrams showing the processes involved in preparation of Filled Milk and Imitation Milk are given in Figure Nos 6.3 and 6.4 respectively.

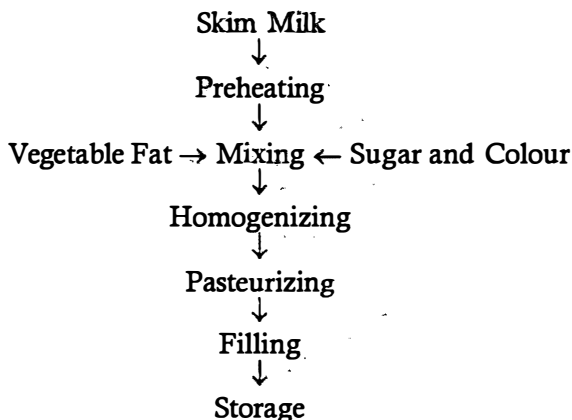


Fig. 6.3 : Flow diagram for Filled Milk

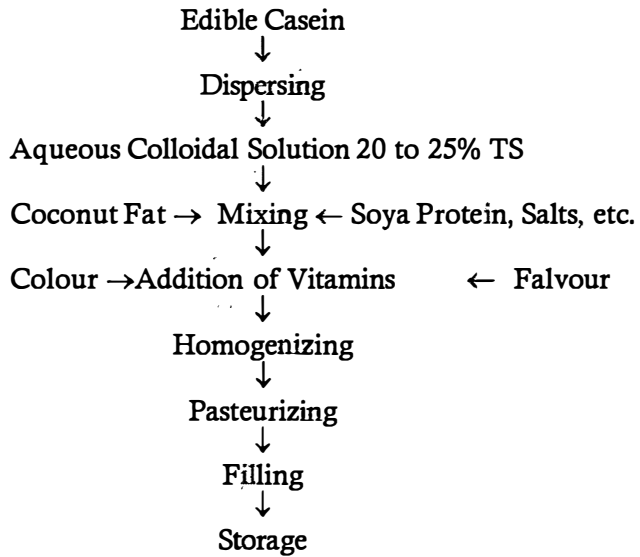


Fig. 6.4 : Flow diagram for Imitation Milk

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Chapter 7.

Cream, Butter and Ghee

Cream

Cream is that portion of milk, rich in milk fat that rises to the top of milk while it is standing, or is separated from it by means of a centrifugal separator. When intended for direct consumption rather than in the manufacture of butter or ice cream, it is called market cream and it must meet the standards for composition and bacterial content of the area in which it is sold.

1. Grades of Cream

The Federal Food and Drug Standard requires light, coffee, or table cream to have 18 to 30% fat; light whipping cream, 30 to 36% fat and heavy whipping or pastry cream to have the minimum of 36% fat. Their approximate composition is as under.

Constituent	<i>Light Cream</i>	<i>Whipping Cream</i>
Fat	19.00%	36.00%
Protein	2.94%	2.20%
Lactose	4.05%	3.15%
Ash	0.60%	0.46%
Water	73.41%	58.19%

Half, and half is a mixture of milk and cream, usually homogenized, which generally contains about 11.5% milk fat; but this may vary from 10.0% to 12%, depending upon local standards.

Gravity-separated cream is cream that has risen naturally to the surface of milk. The fat content varies from 10 to 28% with an average of 20 to 22%.

By means of a special type of cream separator it is possible to prepare cream of 65 to 85% fat content. This product, known as plastic cream, has a heavy body, and when the fat content is 80% or more. Its composition is about that of unsalted butter. It is sometimes used in the manufacture of ice cream.

The cream line or depth of the layer in unhomogenized bottled milk is of considerable commercial importance because the consumer often considers a deep layer of cream as indicative of rich milk. As a result, the attempt is made to produce as deep a cream line as possible for a given fat content of the milk.

The thick layer of cream often found on the top of a bottle of milk or cream is called the cream plug. It is caused by the rise of large fat globules and usually contains from

60 to 80% of fat. This defect occurs more often in milk pasteurized by the HTST method and then homogenized at a temperature lower than that used for pasteurization.

When cream is added to coffee or some other hot drinks, the cream sometimes coagulates with the formation of small, feathery flakes which float on the surface of the liquid. This is known as feathering and it happens often if homogenized or very thick cream is used. If the coffee is made with hard water or the cream is slightly sour, the tendency for the cream to feather is increased.

2. The Cream Separator

The cream separator is essentially a bowl that can be rotated at a speed of 3,000 to 20,000 revolutions per minute. The bowl consists of a series of conical discs, separated from one another by about 0.02 inch by projections upon their surface.

Milk enters the separator in one type of machinery by gravity; in another type, the separator is sealed in an air-tight casing and the milk is pumped into it by a feed pump. Milk enters the machine through holes placed near the center of the discs. As the bowl revolves, the cream, being lighter than the milk or skim milk portion, is driven by centrifugal force towards the center of the bowl, while the skim milk is directed outwards. As the space between the discs is small in relation to the length over which the cream must pass, there is ample time for the cream to rise or separate before it reaches the center of the bowl from which it flows out. An efficient separator will remove all but about 1 to 1.5% of the fat in milk so that the skim milk will contain as little as 0.02 to 0.05% fat.

Fat globules smaller than two microns in diameter are not separated efficiently. The separator may be adjusted so that the ratio of the volume of skim milk to cream is constant, thus permitting separation of cream of a desired fat content from milk of a given fat content. Fig. No - 7.1 shows picture of the Hermatic Cream Separator.

Fig. 7.1: Hermatic Cream Separator

Usually the separator, which may have a capacity upto 20,000 Litres of milk per hour, is operated with milk at 32°C but separators for cold milk are in use which give good separation at 10°C. The cold milk separator has discs about 0.05 inch apart, with the holes near the edge. Hot milk is less viscous and easier to separate efficiently than cold milk. Separators used in the manufacture of dry non-fat milk often handle milk at 50 to 52°C, producing a skim milk with very low fat content.

3. Manufacturing Cream

Much cream, especially that not obtained from Grade A milk, is classified as manufacturing cream. It is used in making butter, ice cream, some varieties of cheese, aerated cream, and similar products. Although the quality of much manufacturing cream is very good, the bulk of it does not meet the standards required of cream for home use.

The grading of manufacturing cream is a quick and simple procedure, but it calls for considerable skill on the part of the grader. A small amount of cream of poor quality mixed with some of good quality may degrade an entire churning of butter. Much manufacturing cream has an acidity between 0.2 and 0.5% expressed as lactic acid (LA), which may place it in second grade; higher acidity would place it in the category of third place.

In addition to acidity, the grader must consider the odor and flavour of the cream. By these properties one can separate cans of cream which will yield butter of different grades or score.

4. Sterilized Cream

Preparation of sterilised cream could be the most profitable form of disposal of the surplus fat in milk. The product is preserved by regulated pre-heat treatment and could be used for a variety of purposes in place of fresh cream. A casual survey of the price of this product in the consuming centres in India will show that the product fetches double the price for unit weight of fat as compared to ghee.

The technique for the manufacture of tinned sterilised cream which needs no refrigerated storage is well known. It has been possible to produce tinned cream with 20 percent fat which has an approximate shelf life of six months. The processing steps for the technique of production of sterilised cream are as follows:-

- (i) Standardisation of buffalo cream with skim milk to a fat content of 20 percent.
- (ii) Pre-heating the cream to a temperature of 85°C.
- (iii) Homogenization of the cream at a pressure of 135 kg/sq. cm. in the first stage and 50 kg/sq. cm. in the second stage.
- (iv) Addition of stabilizers consisting of 0.2 percent citrate and 0.1 percent phosphate of the weight of the cream.
- (v) Canning the cream in 400 gm. tin plate containers.

- (vi) Detection of leaks in cans by immersing in hot water.
- (vii) Sterilisation of the filled tins at temperature of $116^{\circ}\text{C} + 1^{\circ}\text{C}$ for 15 minute in a rotatory steriliser followed by immediate cooling to below 80°C .

Removal of the tins from the steriliser and storage at room temperature.

5. Sweet or Sour Cream

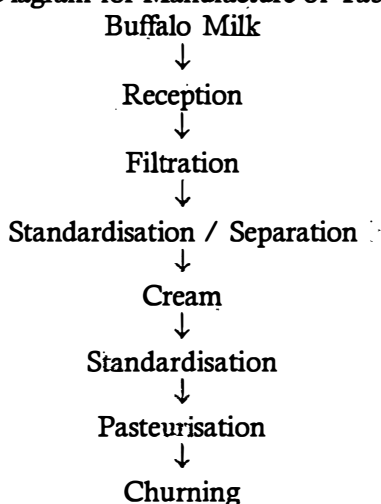
When cream is produced from good quality milk of not more than 0.14% LA and free from neutralizers it is called sweet cream. Whereas cream from milk with more than 0.17% LA should be considered as sour cream. It is produced after neutralizing the milk and passing it through separator at 40°C to 45°C . The sweet cream is often standardized to the desired fat content.

6. Packing of Cream

Generally the cream is packed in sterilized aluminum cans of 40 lit. capacity and properly covered but with air vent. As per market requirement the cream is pasteurized and packed in polyethylene pouches. Non pasteurized cream may be packed only in bulk packing of 15 kg capacity double lined polyethylene bags and covered by craft paper bags. This is used for ghee manufacture only. When offered in consumer packs, the pouches of cream shall have the Name of the manufacturer, MMPO Regn No, Type of cream with fat%, Contents (500 ml/ 1000 ml), Maximum Retail Price, Batch No and Date of packing and indication of Best before 7 days 'under refrigeration at 5°C '.

BUTTER

Butter is one of the most important dairy products widely consumed all over the world. Fig. No- 7.2 Shows Flow Diagram for Manufacture of Table Butter.



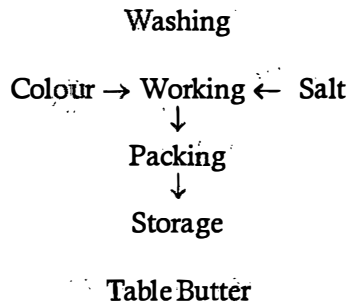


Fig. 7.2: Flow Diagram For Manufacture for Table Butter

The salted variety called as Table Butter is used as bread spread whereas unsalted (Cooking, desi) butter is used as such in cooking or as intermediate product for conversion into ghee. Although it appears to be simple, its acceptance by consumers largely depends on application and adherence to various factors in the processing of cream and its actual churning into butter.

Various defects may arise in butter which are classified as per Flavour (Acid, High acid, Neutralizer, Bitter, Cheesy, Cooked, Feeds and weeds, Fishy, Rancid, etc); Body and Texture (Greasy, Gummy, Crumbly, Leaky, Grainy, etc); and Colour (Mottled, Wavy, Pale). These defects can be prevented/overcome by taking necessary precautions and corrective measures during the various processes as given below.

(1) Standardization of the Acidity of Cream

The reasons for standardizing the acidity of the cream may be listed as follows:-

(1) Control of the flavour of the butter. (2) Control of the amount of fat lost during churning. (3) The manufacture of butter or desirable texture. (4) Control of the quality of the butter. (5) Manufacturing butter of uniform quality for day to day usage.

(2) Neutralization of Cream

2.1 Type of Neutralizers

There are two general types of neutralizers available-the soda compounds and the lime compounds.

The soda used in cream neutralization are

1. Sodium bicarbonate – NaHCO_3
2. Sodium carbonate - Na_2CO_3
3. A mixture of sodium bicarbonate and sodium carbonate.

These are relatively mild alkalis. A stronger alkali is a mixture of sodium hydroxide (NaOH) and sodium carbonate (Na_2CO_3) and also straight caustic soda (NaOH).

The limes used in cream acidity standardization are : (1) Hydrated lime known as calcium hydroxide $\text{Ca}(\text{OH})_2$. (2) A mixture of calcium hydroxide and magnesium oxide. (3) A mixture of calcium oxide (CaO) and magnesium oxide (MgO).

2.2 How to Use Neutralizers?

In a small or medium sized creamery, it is most convenient to weigh the neutralizer necessary for each vat of cream. In a large plant a stock solution may be prepared. The required amount of this stock solution is then diluted before it is added to the cream.

2.3 Using Two Neutralizers

With cream that exceeds 0.65 percent acid, it is advisable to first neutralize it with lime and then with soda.

The practice of using two neutralizers with high acid cream is well established and is generally practiced. Some butter makers neutralize down to 0.45 to 0.50 percent with lime and then with soda to the desired acidity. Others follow the practice of neutralizing with lime 1/3rd of the acidity to be reduced and the other 2/3rd of the acidity with soda.

2.4 Amount of Acid Reduction

This is an important part of the buttermaker's responsibility. The acidity should be reduced sufficiently so that: (a) The flavour of the fresh butter is satisfactory. A neutralizer flavour must not be present. (b) The loss of fat during churning will be at a minimum. (c) The butter is not mealy. (d) The butter can be safely stored, if necessary, for an extended time without the development of an oily-fishy or tallowy flavour.

Correct neutralization to an acidity slightly above the neutral point, as measured by the titration method, using N/10 NaOH and phenolphthalein, eliminates coarse-acid flavour, but if the cream is neutralized to a point that will result in butter with a serum pH of 7.0 (neutral), the flavour will be flat, or insipid.

The serum pH of the butter made from such cream will range from 6.6 to 6.9. If the butter is to be stored for several months, neutralization to an acidity that will give a pH of the butter serum which is neutral (7.0 ± 0.1) has been found most satisfactory in order to preserve the original flavour of the butter and avoid storage defects.

2.5 Prevention of Neutralizer Flavour

Excessive or improper use of neutralizer may result into neutralizer flavour. This can be avoided by taking following steps:

(a) Have the cream in a homogeneous condition.

- (b) Heat the cream slightly if it is cold and thick.
- (c) Use a mild neutralizer with cream of medium or low acidity.
- (d) Use two neutralizers, lime and soda, with high acid cream.
- (e) Add the correct amount of well-diluted neutralizer solution to the cream.
- (f) Spray the solution slowly into the cream while it is being stirred.
- (g) Add sufficient neutralizer so that the butter serum will have a pH from 6.6 to 7.0 depending on whether the butter is to be consumed soon or is to be stored.

2.6 Prevention of Mealy Texture of Butter

- (a) This undesirable defect will be present in butter when the cream either has been under-neutralized or over-neutralized. If the cream was under-neutralized, extensive hardening of the casein takes place. The particles of casein become embedded in the butterfat.
- (b) When the cream, especially high-acid cream, has been over-neutralized with lime, because of the affinity of casein for calcium, large aggregate particles of casein and lime are formed. These also will become embedded in the butterfat. The butter will be pronouncedly mealy or grainy.

To avoid these defects it is necessary to add right quantity of neutralizer.

2.7 Neutralizing a Mixture of Sweet and Sour Cream

When a considerable amount of sweet cream is to be mixed with sour cream in the vat, it is desirable to neutralize the sour cream first. If this is not done then the butter may have a sour or vinegary flavour, and if curdling takes place during pasteurization mealy textured butter will be produced.

It is advisable to always neutralize the sour cream before it is mixed with the sweet cream. A better plan is, of course, to pasteurize and churn the sweet and the neutralized sour cream separately.

2.8 Correction of Over-Neutralization

If some fine-flavoured starter, or some cultured buttermilk is available, the addition of two or three cans of these to the vat of cream would have a beneficial effect and it would be possible to obtain butter of nearly the desired pH value.

(3) Pasteurization, Cooling And Storage of Cream

The following three methods of pasteurization have been commonly used for cream:

1. **The Steam Injection System** : Steam is injected through small orifices directly into the cream passing through a pipe.
2. **The Vat-Holding Method** : The cream is heated, by hot water in a jacket or coil, to the desired temperature. It is then maintained at this temperature for the required period of time.

3. **The High-Temperature Short-Time Method :** Milk or cream is continuously heated by hot water passing in a thin layer between stainless steel plates. Or through tubes, to not less than a minimum temperature of 160°C. Subsequently the product is not permitted to fall below the minimum temperature while passing through a pipe or tube during a period of not less than 15 seconds before it is cooled.

Cooling Cream after Pasteurization

With the vat method of pasteurization, at the end of about one-half hour holding period, the cream should be cooled as quickly as possible to a low temperature. Slow cooling is detrimental to the butter quality. On account of the excessive agitation, partial churning may take place and greasy or leaky-textured butter results.

Storing Cream after Pasteurization and Cooling

When cream is high-temperature pasteurized by the continuous method and cooled by means of a plate or surface cooler it should be stored until the time of churning in a vat where the temperature can be accurately controlled and where there will be no contamination with microorganisms.

(4) Addition of Starter

A desirable flavour can be imparted to the butter by the addition of three to five percent by volume of a high quality starter to the cream. The best plan is to add the starter to the cooled cream during the late afternoon and churning the cream in the coming morning. An increase in the acidity of the cream containing starter during the holding period should be avoided.

To obtain considerable flavour in butter the acidity is relatively high (low pH), say upto 0.25 percent lactic acid. But the butter made from the higher acid cream does not keep as well during storage as that made from low acid cream. In other words high flavour and good keeping quality during storage do not go together.

When manufacturing unsalted butter, a larger percentage of starter may be used and the cream may be ripened to an acidity to between 0.40 to 0.50 percent lactic acid.

Assuming that the starter used is of excellent quality, the following two defects may occur if the starter is not correctly used: (1) in fresh butter-high acid and coarse flavour; (2) in storage butter-oily fishy flavour.

If starter is used correctly the benefits are :

1. It imparts a more desirable flavour to the butter. The flavour of fall and winter-made butter is often flat.
2. It prevents the development of certain undesirable types of bacteria in butter, particularly in unsalted or low-salted butter.
3. It makes less pronounced certain undesirable flavours, such as feed, tallowy, neutralizer and scorched flavour.

4. It aids making butter of a more uniform quality throughout the year.

(5) Churning Of Butter

Metal churns constructed of Stainless Steel are now being used in many creameries. Churns constructed of stainless steel are being manufactured in Canada, Denmark, Sweden, Germany and India.

Most of the churns are equipped to operate from four to nine speeds that vary from one-half revolution per minute to 30 RPM. Fig. No – 7.3 shows picture of Metallic Butter Churn, and Fig No – 7.4 shows Picture of A Continuous Butter Making Machine

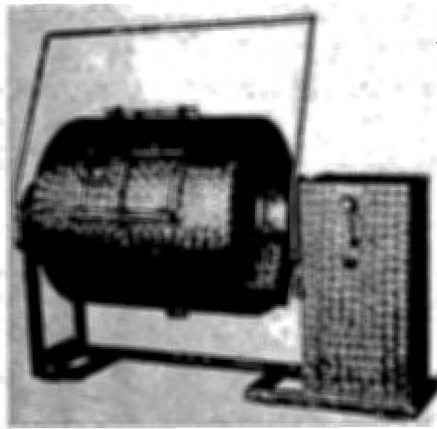


Fig 7.3: Metallic Butter Churn

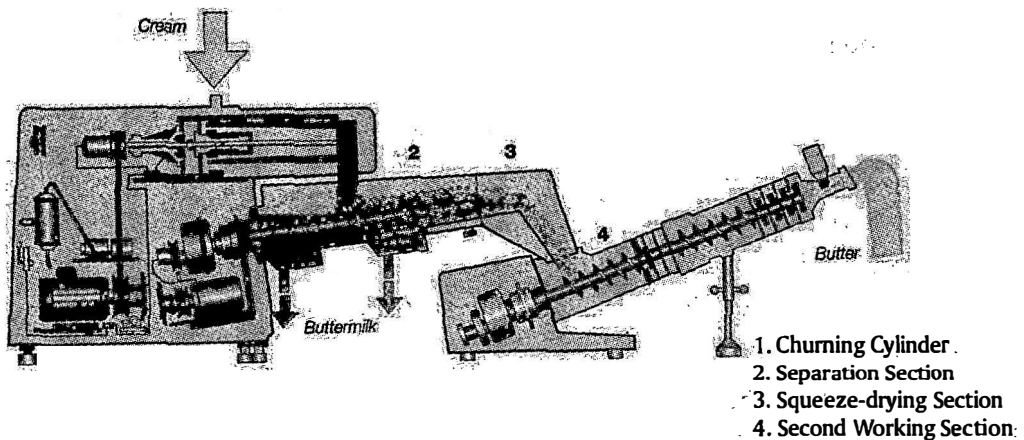


Fig. 7.4: A Continuous Butter Making Machine

- i) **Cleaning of Stainless Steel Churn:** Add hot water, as near the boiling point as possible, in an amount equal to 10-12 percent of the churn capacity. Add 0.2 to 0.3 percent of a fat emulsifying cleaner such as trisodium phosphate. Revolve the churn for about 5 minutes at high speed. Drain the water and rinse the interior; then add water at a temperature near boiling, and revolve the churn for a few minutes followed by draining. During the cleaning, the vacuum valve must be open to enable rinse air to escape valve.
- ii) **Preparation of the Pump, Pipes or Strainer and Churn for Churning:** Before the cream is transferred to the churn, the pump, sanitary pipes and filter or strainer should be either (a) rinsed with hot water, (b) steamed, or (c) rinsed with a chlorine solution containing 100 ppm of available chlorine. Cooling is done by running pure water through the equipment.
- iii) **Factors that Determine the Temperature of the Cream for Churning:** The temperature of the cream should be such that under normal conditions the churning will be completed in 40 to 50 minutes, counting from the time the churn is started until the buttermilk is drained. Churning at too low a temperature is undesirable because the fat globules are so firm that they do not readily adhere together. The churning is delayed. Churning at too high a temperature is also undesirable because the fat globules are soft and form granules too quickly. This causes an excessive loss of fat in the buttermilk and may result in greasy and leaky textured butter.
- iv) **Volume of Cream placed in the Churn:** The volume of cream of average fat content and of proper temperature should be such that there will be sufficient agitation of the cream during churning to give a churning period of 40 to 50 minutes. If the churn is too full, the amount of agitation is reduced. If there is too little cream in the churn, the agitation may also be reduced. The speed of the churn drum during churning will be approximately 25 to 30 rpm depending upon the type of churn.

If the churn is underloaded, it would lead to following problems.

Greatly underloading the churn results in:

1. Poor agitation, causing insufficient churning.
2. Rapid rise in the temperature of the cream.
3. Difficult working which may result in uneven colour.
4. Difficult composition control.

As against this if the churn is overloaded it would result into:

1. Insufficient agitation, causing prolonged churning.
2. Inferior body and texture. If the churning temperature is raised above the normal in order to churn faster, the loss of fat in the buttermilk will be higher and the body and texture of the butter will be inferior.

3. **Defective colour.** Because of the excessive amount of butter, it is difficult to work the butter satisfactorily. The butter may have an uneven colour. Composition control is difficult.

In the event the churn has been overfilled and butter granules will not form, the best remedy is to remove from four to six cans of cream and add this to the next churning. Do not add it to the cream in the churn at the time of breaking. This will result in an excessive loss of fat.

Sweet cream, because of the greater viscosity of the serum, churns more slowly than sour, neutralized cream or cream that has relatively high acidity at the time of churning.

The slight pressure inside the churn after the churn has been revolving with the cream for several minutes is due to the giving off gas, principally carbon dioxide and air during the beginning of the churning process. Open the vent to reduce pressure, then close it.

The churn should be stopped when the butter granules from average testing cream are of the size of small peas. The granules should preferably be irregular in shape so that a large surface is exposed. This facilitates a thorough washing and chilling of the granules.

v) Effect of Overchurning

Overchurning is usually the result of churning the cream at too high a temperature. This is undesirable because:

1. The butter granules cannot be washed and chilled properly.
2. Composition control becomes difficult.
3. The texture and body of the butter will be defective (leaky and greasy).
4. The flavour may be coarse.
5. The keeping quality of the butter is jeopardized.

As against this the running of churn for shorter period will be leaving too many fat globules in the buttermilk and escape of small butter granules when draining the buttermilk.

vi) Draining the Buttermilk

The buttermilk should be drained as quickly as possible after the churning process has been completed. Slow removal, especially when high acid, lime-neutralized cream is churned, results in setting of curd particles in the bottom of the churn. If the butter granules are soft they may pack together, making the washing process less efficient.

(6) Washing of Butter

Washing the butter granules is a very important step in production of butter. It helps to remove most of the butter milk that adheres to the surface of granules and the inside

surface of the churn and generally improves the keeping quality of butter by removal of milk serum contained in buttermilk. Further, it aids in developing proper body and texture of the butter and helps to remove objectional flavours and controlling the final composition of the butter.

Temperature of the Wash Water

Normally the temperature of the wash water is several degrees lower than the temperature of the cream used. The lower temperature causes firming of the butter granules and facilitates a thorough mixing during working of the butter constituents. If the temperature of the wash water is too low, the butter is too hard for efficient working and composition control. The butter is leaky if not worked enough, and becomes sticky if it is overworked.

If the temperature of the water is too high, the butter may be too soft to allow for a thorough working. If not worked enough, the butter may be leaky and if it is overworked it may become salty or greasy. Composition control also becomes difficult. A fairly low temperature of the wash water aids during the winter season in producing butter which is reasonably soft after it has been kept in the refrigerator for a day or two.

When the butter granules are very soft as a result of using a too high churning temperature or churning too soon after pasteurization, the addition of very cold water causes a hardening of the outside of the granules. The butter may have a grainy texture and a mottled colour. The texture may be leaky.

General Procedure of Washing the Butter

1. When the buttermilk has practically all drained out, spray a small amount of filtered pure water over the granules and let this drain out of the churn.
2. Close the gate valve on the churn and add through sprayer as much water as there was buttermilk, or as much as cream for all and winter butter. Close the churn door.
3. Revolve the churn in high gear about 10 to 15 revolutions.
4. Drain all the water.
5. Drain practically all the water through the door opening.
6. During the season of the year when there is a danger of the butter granules retaining too much water, pre-work the butter before salting and drain the water present out.

One washing properly done is sufficient with average high quality butter. Additional washings are time consuming, expensive, and unnecessary. Over washing removes flavour and may cause the butter to have a flat flavour. With low-quality butter, a second washing may aid in removing some undesirable flavour.

(7) Salting of Butter

The main purpose of salting the butter is to season the butter so that it will have a higher relish and at the same time it would prevent the growth of bacteria, yeasts and moulds. Also, the addition of salt has to be as per the liking of consumers. As a thumb rule, the salt content of about 2.5 percent appears to suit most of the consumers. Oversalting is definitely objectionable since that butter has a coarse, briny flavour.

(8) Colouring of Butter

Since the natural colour of the butter may vary due to season, type of fodder, breed of animal etc., the practice of applying colour to the butter is followed all over the world which is appreciated by consumers as well. The vegetable colour, which is most commonly used is a refined vegetable oil extract of the seed of the annatto tree 'Bixa Orellana'. The seed is white inside having a thin coating of colouring matter that contains two different colours: (a) Bixin, which is yellow, and (b) Orellin which is red. The other colour used is a coal-tar dye, which is harmless and oil-soluble. However, this dye must be certified as to be harmless for use in food by the Food and Drug Administration. The third option is to use natural Carotene obtained from carrots or made synthetically.

Amongst all these options the annatto colour is preferred. The concentrated annatto butter colour is now obtainable which is five-and-a-half times as strong as regular vegetable annatto colour and two-and-a-half times as strong as certified butter colour.

(9) Working of Butter

The butter should be worked until all the free brine has been incorporated with the butter so that an accurate determination for moisture can be made. It should not be worked finished. If the butter is under worked, it will be difficult to make a determination for moisture, and if worked to completion, it will not be possible to add additional water without overworking the butter. If it is worked finished there is no opportunity to add more water.

(10) Packing of Butter

The butter is packed in bulk in 20kg butter hoops and pressed so as to remove air holes. Then it is removed and placed in a polyethylene unprinted sheet and further placed in 5 ply corrugated box (38 cm x 27 cm x 24 cm-height). The box should have printed matter as mentioned under the cream.

As per market requirement the butter may be packed in 100 gm/500gm denomination by using press mold and then wrapping the blocks in a grease proof butter paper which is impervious to light, flavouring and aromatic substances; and then placed in polyethylene pouch or card board cartons. The pouch or box should have printed matter as mentioned under cream packing. Fig : 7.5 Shows Picture of Butter Packing Machine.

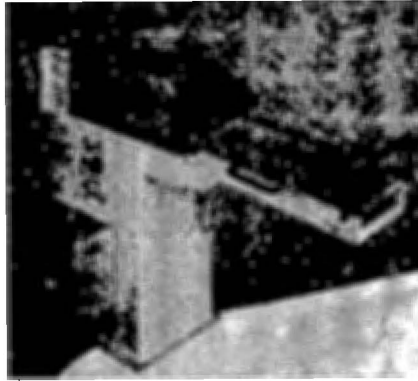


Fig. 7.5 Butter Packing Machine

(11) Storage of Butter

Butter is always stored at minus 15 to minus 20°C temperature. If it is meant for conversion then it can be stored at sub zero temperature. The boxes or containers holding cartons are placed on wooden pallets placed six inches away from wall and 3 inches above the ground level of the cold storage. The stacking of boxes / containers is done in tapering manner from the delivery door side to the blower end. The deliveries are to be made on first in first out basis. When the temperature of the butter is minus 15°C, it can be transported in any vehicle over a transit period of 20 hours. However, when the temperature is 3°–4° C, the vehicle should be insulated and the transit period should not exceed eight hours. At the outlets the butter should be stored in refrigerators in freezer or in deep freezer.

Ghee

Ghee is the common form in which butterfat is used in India. It is a more convenient and more acceptable form than butter in the warm climate. Butter has a shorter storage life than ghee because the water and milk solids present support the growth of bacteria.

In India, ghee is traditionally prepared from buffalo milk which has a higher fat content than cow's milk and contributes more than 54 percent to total milk production.

Although ghee, made in India, and anhydrous milkfat (AMF), made in Australia, both consist of 99 percent milkfat and contain traces of moisture, the two products are very different in taste, smell and physical appearance. Ghee has a rich pleasant flavour, is high in free fatty acids and has a granular texture, whereas AMF has a bland flavour, low free fatty acids and is not usually granular.

Composition of Ghee

Ghee is mainly the extracted fat of milk, but it also contains traces of other substances, including up to 0.3 percent moisture. About 0.5 percent of ghee is unsaponifiable matter

like sterols, fat-soluble vitamins and hydrocarbons. In addition to fat and unsaponifiable matter, there may be other constituents depending upon the history of the ghee sample. These include free fatty acids, phospholipids and various fat breakdown products like hydroperoxides, aldehydes, ketones and traces of minerals including calcium, magnesium, cobalt and iron. Ghee also contains dissolved gases including nitrogen, oxygen and carbon dioxide. Unlike cows' milk, buffalo milk does not contain carotenoids, hence ghee prepared from buffalo milk is white in colour.

Properties of Ghee

The flavour, texture (granularity) and color of ghee have long served to characterise and identify the product. A pleasant nutty, lightly cooked or caramelized aroma is generally prized. Granularity is considered by the buyer as an important criterion of quality and purity. The solid phase of ghee should be of well defined granular structure and the color, which should be uniform throughout, should be white, with or without a yellowish or greenish tint.

Production of Ghee

Ghee is manufactured in India in almost all the households. The process begins by fermenting whole milk to curd, churning the curd to butter and finally boiling down the latter to give ghee.

This product has a poor keeping quality and yields are low. However, with the centralised industrial production of ghee, techniques have been developed to produce a high uniform quality ghee. There are three batch processes for commercial ghee manufacture as well as a continuous process. Fig. No. 7.6 shows Flow diagram (Batch Process) for Manufacturing Ghee.

Batch Methods:

1. The Cream Butter method.
2. The Direct Cream method.
3. Pre-stratification method.

Each of these processes is outlined in Figure No - 7.6. High heat (About 110° to 120° C) is applied to butter or cream in an open jacketed vat to remove moisture with agitation. The selection of each method depends on fat recovery, fat quality and ease of adapting to an industrial scale. Regardless of the method, the flavor of the final product is improved by initial ripening of the cream.

In the cream butter method, the separated cream is churned into butter which is thereafter converted into ghee, whereas in the direct cream method, cream is directly clarified to give ghee. The boiling down of cream to ghee is a slower process because of the stability of the emulsion. The cream butter process has higher yields and produces ghee of good sensory qualities and better keeping quality.

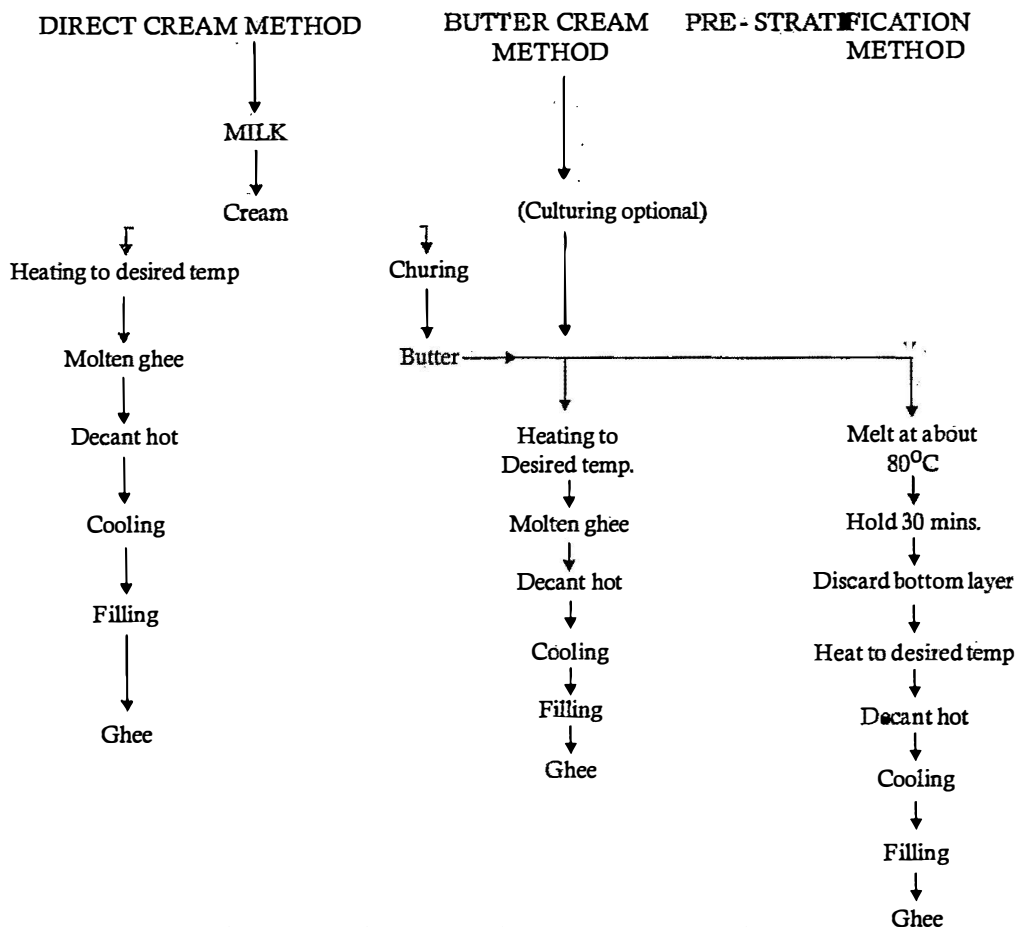


Fig. 7.6: Flow diagram(Batch Processes) for Manufacturing Ghee

In the pre-stratification method, the bottom layer of molten butter is discarded and the remaining layer is heated to the desired temperature. In this way, advantages in economy of fuel, and production of ghee with low acidity can be achieved.

Continuous Methods:

This process, which is semi-automatic, requires less manpower and time. Uniform quality, hygienic operation, and high fat recovery are additional advantages.

The Unit is of a two/ three stage pressurized scraped heat exchanger attached to vapor separators. The cream or butter is received in a jacketed receiving vat from where it is pumped to the first stage of the heat exchanger system.

The cream/butter is heated under pressure with the help of steam in the outside jacket. The superheated liquid (cream/butter) is then flashed into a vapor separator where the

super heat in the liquid is converted into latent heat of evaporation and some portion of the water is converted into vapor.

The vapor separator separates the water vapor from liquid fat. The cream/butter with partially removed water then goes to the next stage for further removal of moisture. If butter is used as a raw material, a two-stage process is sufficient, however for cream, a three-stage process is necessary. Finally, the sediment in the product is removed by clarification. Fig. No. 7.7. Shows Diagram of Continuous Ghee Making Plant.

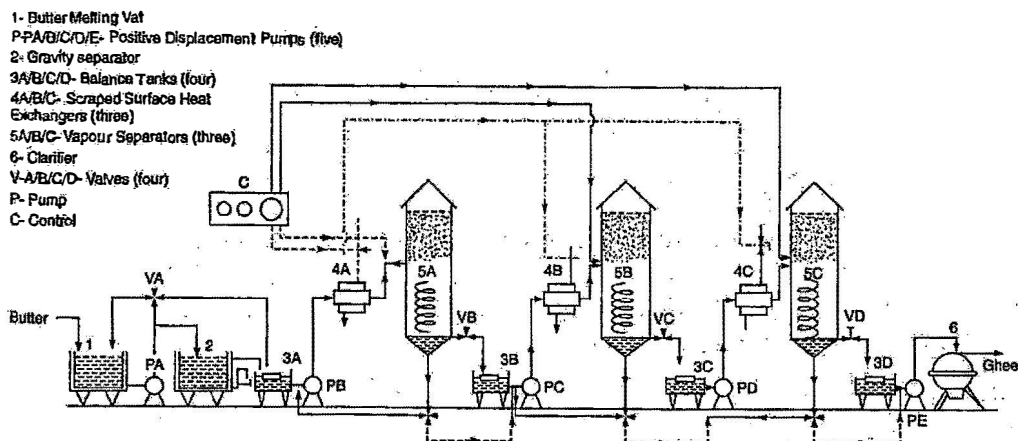


Fig. 7.7: Diagram of Continuous Ghee Making Plant

Packing of Ghee:

According to the schedule III, Rule 5 under the weights and Measures Act 1976, the ghee has to be packed in the denominations of 50 gm, 100 gm, 200gm, 500gm, 1 kg, 2kg, 3 kg, and thereafter in multiple of 5kg. Generally the quantities upto 500 g are packed in polyethelene pouches using a film of minimum thickness of 100 microns (LDPE mixed with nylon) which is pigmented and leaving clean blank surface for vertical / horizontal sealing. These pouches are further packed in 5 ply corrugated boxes, each holding the quantity of 10 kg i.e., 50 pouches of 200gm or 20 pouches of 500 gm.

The poly PET jars (stretch blown) are also used with HDPE lids to pack ghee. According to the denomination, the suitable size and shape is to be decided. For example to pack 500 gm, the PET jar should have volume of 507 ml, weight of $26 \text{ gm} \pm 2 \text{ gm}$, diameter of 56 mm and the lid should have weight of 6 gm and diameter of 56 mm. These jars are sealed by circular aluminium foils and then lids applied. Ghee thus packed in PET jars is also further packed in 5 ply corrugated boxes, each holding 10 kg (20 jars of 500 gm).

Alternatively ghee in smaller denominations is also packed in aluminium foil and outside container in a simultaneous manner called as rollatainer. Nowadays ghee is also packed in aluminium foil pouches which stand on their wide base in a vertical manner.

In higher denomination ghee is packed in tins. The largest being 15 kg. The tins may be as per the standards of BIS (lacquered) or otherwise with dimensions of 24 cm x 24 cm x 33.5 cm height. Each tin is further packed in 5 ply corrugated box.

Whatever be the method of packing or the denomination, the actual pack viz., pouch, jar or tin and the secondary package of corrugated boxes have to be labeled with all the particulars viz., Dairy's name, Address, MMPO Regn. No, Product name (i.e., Ghee), Contents in weight / Volume, Batch no, Date, Month and Year of packing, Best before, and MRP (inclusive of all taxes).

Granulation of Ghee

Ghee which is granular in texture is appreciated by consumers all over the world. To develop this character the ghee containers are allowed to stand for 24 hours at 25°C temperature. In the case of PET jars the sealing with aluminium foil is done only after granulation, otherwise ghee is recycled and packed.

Quality Checks of Ghee

Since ghee is offered to the market with a shelf life of several months, when stored at room temperature; it is better to subject it to various quality checks for all the batches. The organoleptic tests should be carried out for aroma / flavour, texture, acidity, colour, suspended matter and packing. Apart from this it should be tested for moisture (not more than 0.5%), fat (not less than 99.5%), acidity (free fatty acid not more than 2%) and peroxide value below 1.5%.

Storage of Ghee

Ghee in all packing is stored in cool, dry place. The boxes are placed on wooden pallets with not more than five stacks. During transportation also, the number of stacks are limited to five.

Chapter 8

Fermented Milk Products

Dahi, Yoghurt, Lassi, Shrikhand, Others

The fermented milk products by and large are preferred over milk by many consumers due to several reasons. The foremost is that the fermented milks are much more palatable and even aged people, adolescents and children who otherwise would not like to take milk would readily take them. Secondly, fermented milks readily have increased nutritive value and they are easily assimilated by human system than milk. It is claimed that the percentage assimilation of fermented milk and that of milk after 1, 2 and 3 hours after consumption is in the order of 91, 92 & 95 and 32, 36 & 41 respectively. Further, the fermented milks may contain antibiotics which have inhibitory effect on the intestinal organisms producing toxins and even on pathogenic organism like *M. tuberculosis*. Thirdly, they may contain small amounts of CO₂, alcohol etc., which excite respiratory centre and central nervous system so as to cause increased oxygen flow to the lungs thus, improving the oxidation reduction process in the human system. As a result certain fermented milks could be used therapeutically to cure various diseases such as dysentery, typhoid, gastritis or other ailments like anaemia, inflammation of gall bladder, prostate gland and kidney stone. Due to these reasons it is no wonder that the fermented milks have been accepted as health promoters everywhere. As a result their consumption has been increasing and their commercial production is promising.

Although various types of fermented milks are produced there are certain common factors in their production as under:

Production of Fermented Milks:

1. To ensure that the product offers health benefits and consumer satisfaction, the milk should be selected properly. Milk from cow or buffalo and even recombined or reconstituted milk could be used provided they are free from undesirable flavours or odour. Milk of poor quality with unpleasant flavours should not be used.
2. Clarification or filtration of milk may be necessary to remove visible dirt and other materials thereby reducing the bacterial load.
3. Standardization of milk is mainly done in respect of the solids, non fat content (SNF) of the milk. The fat content may be adjusted either by addition of cream or skim milk or by partial separation. Normally 2.5 to 3% fat would be adequate

to give a rich flavour. The SNF content can be increased by addition of concentrated milk or skim milk powder. In a product like yoghurt the SNF content may be raised upto 15%.

4. Warming and homogenization of milk at 100 to 150 kg/cm² pressure is desirable. Alternatively homogenised milk itself may be used during standardization. The homogenization imparts rich flavours even with low fat levels and helps to maintain the texture and body of the final product and reduces the “wheying off”
5. The milk is heated at 90°C for 15 to 30 minutes or at a higher temperature for short time. The heat treatment may be given either in a tubular vessel or in a double jacketed vat provided with stirrers.
6. The heat treated milk is cooled to a temperature at which it is to be inoculated. The temperature depends upon the type of product and the starter culture used for fermentation. In the case of yoghurt, where the ripening is carried out at 40-45°C the milk is cooled to a temperature which is higher by 2°C than that. This practice helps to prevent the temperature of milk falling below the standard temperature at the time of inoculation.
7. The packing depends upon the type of the product. Dahi may be packed in bottles with wide mouth (55 mm) or paper cartons waxed or laminated with plastic or aluminium. In the case of yoghurt the waxes used should be low volatile to withstand the higher temperature used for ripening. Fermented milks with thinner consistency and having gaseous or alcoholic fermentation, should be filled in narrow necked bottles and crown corked. Inoculated milk can be packed in polyethylene pouches on Form-Fill-Seal machine and further allowed to incubate to thicker consistency Dahi. The packing should provide information regarding Name, Address, MMPO Regn. No. of the dairy and Product composition, Contents, Date of packing, Best before, MRP, etc. as per legal requirements.
8. The incubation is carried out in thermostatically maintained rooms or cabinets. The stacking of the crates is done with adequate spacing for circulation of warm air and uniformity of temperature in the incubation chamber. This is important for yoghurt which is kept for a short duration of 3 to 4 hours only.
9. Cooling of fermented milk is necessary when a certain level of fermentation is reached. After cooling of yoghurt where the ripening is at a higher temp of 44°C, the cooling is done in two stages – first at atmospheric temperature or by a blast of cold air and thereafter by cold water. This also reduces the refrigeration load.

These are the basic factors common for production of most of the fermented milks. The specific requirements and characteristics of certain important products are given below.

Dahi

Production:

All the basic factors described above are applicable to Dahi. Dahi of high quality should have a firm texture, mildly sour taste and pleasant flavour. Such a product can be obtained only by using the right type of starter cultures and adopting scientific methods of preparation. For its preparation, good quality milk is taken in clean, stainless steel or heavily tinned utensil and then the milk is heated to first boil or heated to a temperature of 85° – 90°C for 10 minutes and then cooled to lukewarm temperature (about 30°C). The starter culture (either a portion of the stock culture maintained separately of small quantity of the previous day's Dahi) is added to the milk at the rate 2 to 3 percent (about two table spoonfuls of the curd to each kg. of milk) and is mixed well. After closing, the vessel is kept in a warm place during winter or a cool place during summer to maintain the temperature at about 25°–30°C. Normally Dahi will be formed into a firm curd with good flavour development in 18 to 24 hours.

YOGHURT

Yoghurt, like acid dahi has a thick consistency and pleasant acid taste and aroma. It may be with a firm set or may be “stirred Yoghurt”. Various modifications with addition of fruits juices, flavours, etc., have been developed to suit the consumer's taste.

Production:

Yoghurt is prepared by fermenting milk with a mixture of *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. The production of high-quality product uniformly, from day to day, involves careful handling of the various operations in the manufacturing process.

Selection of Milk

Yoghurt may be made from whole, skim or standardized milk. The conventional method uses precondensed milk. In modern methods of manufacture, instead of precondensing the milk, either skim milk powder or concentrated milk is added to the milk to increase the total solids content by 3 to 6%. The increase in milk solids is to get a more firm coagulum. Trials conducted at National Dairy Research Institute, Karnal, showed that the SNF content of milk should be more than 10% to get a firm coagulum. With good quality buffalo milk, fairly good yoghurt can be obtained if subsequent heat treatment is done in an open vessel where evaporation might increase the total SNF content. The minimum fat content was found to be 2.5% since the taste was found to be flat in samples having lesser fat content. Yoghurt can also be prepared from skim milk but it will not have a smooth texture. The most important point in the selection of milk is that it should be completely free from antibiotics and other inhibitory materials since the yoghurt cultures are highly sensitive to them.

Pretreatment

Milk is generally homogenized before heat treatment. It is heated to about 55° to 60°C and at one stage homogenised at pressures varying from 1,500 to 3,000 p.s.i. homogenization prevents the rising of fat to the surface and formation of a crusty layer. Viscosity of finished product is also improved. Some plants dissolve the milk powder after heating the milk to 55-60°C before clarification. Standardization of the milk can also be done by adding homogenized cream to the skim milk, fortified with skim milk powder.

Heat treatment of milk is preferably done in a cylindrical jacketed vat (such as cream pasteurizer) provided with a good agitator. Such a vessel has the advantage that the milk is not only heat-treated but can also be cooled subsequently. The temperature used varies from 85-90°C with holding time of 30 minutes. This time-temperature combination helps in getting (i) a firm curd and thicker consistency, (ii) a homogeneous and viscous product on breaking and dispersion, and (iii) reduced tendency of whey separation during storage. The milk is then cooled to about 45°C for inoculation. Alternate heat treatment such as at 130°C for 15-45 seconds or 140°C for 15 seconds have also been found to be satisfactory for curd formation, but the viscosity of the product was found to be less.

Inoculation

The cooled milk held at 45°C is inoculated with culture in proportion of 3% by weight with a yoghurt culture, consisting of *S. thermophilus* and *L. bulgaricus*. Usually the proportion of streptococci to lactobacilli is 1:1. However, some manufactures feel that the proportion should be 3:1 or 2:1, It is often desirable to make pilot trials using these combinations and select the best for specific conditions.

Packing

After inoculation and thorough mixing with the help of agitator, the mixture is filled in suitable containers. The most common containers are glass, plastic cups or paper cartons.

Plastic cups and paper cartons are popular as single-service containers. The essential points to be looked into the selection of plastic containers are (i) their mechanical strength to prevent collapse during handling, and (ii) freedom from release of volatiles at temperatures upto 90°C so that off flavours are not imparted to yoghurt. The most popular type is polystyrene injection moulded "tub" of 0.02 to 0.25 mm in thickness.

Incubation

The filled cups are incubated at 42-45°C for the coagulation to take place. Incubation may be done in a water bath or in an air incubator room. The advantage of water bath

is that the uniform temperature is maintained during incubation and subsequent cooling is done in the same unit.

Incubation is done for 3 to 4 hours. Usually the last cup in the incubator is examined for coagulation. A firm coagulum without breaking of the curd when tilted should be obtained. Often the acidity or pH of curd at this stage is checked. In practice, if the incubation and subsequent cooling is done in a water bath, the acidity at removal is usually between 0.65 to 0.7% of pH or 4.7 to 5.0. However, if incubation and subsequent cooling is to be done in air, fair amount of acid production may continue due to slow rate of cooling, and therefore, the containers should be removed at a lower acidity of 0.5 to 0.55%. In general, the acidity to be kept at the time of removal depends upon the method of cooling to be adopted as well as the final acidity desired for the finished product.

Cooling

After the curd has formed, the containers have to be cooled to arrest subsequent acid production and avoid the risk of whey formation.

Keeping Quality

If stored at 2-5°C, yoghurt can retain its characteristic taste and flavour upto 10 days.

Varieties of Yoghurt

(a) Stirred Yoghurt

This will be in the form of a thick, viscous product. Here the yoghurt is allowed to set, and is then cooled in the vat itself. After the temperature has come below 65°C, it is gently stirred to make it homogeneous. It is then filled either by gravity or with the help of a pump. The most essential point to be remembered is that minimum air incorporation should be allowed during stirring or filling, as otherwise, whey separation will occur. The containers are then transferred to the cold store.

(b) Fruit Yoghurt

Flavoured yoghurts have become quite popular in many countries in recent times. These flavourings may be obtained by the addition of fresh or deep-frozen fruits, fruit concentrates, fruit pulps, fruit flavours or even fruit powders. The most popular flavours are mango, strawberry, apricot, raspberry and black currant followed by pineapple and orange.

Depending upon the type of flavouring material the manufacturing procedures also may be modified. Liquid flavour materials or fruit powders (after making into a paste) are generally added to milk before homogenization and heat treatment, so that they are not only uniformly mixed but also rendered free from pathogenic and other

undesirable organisms. Pineapple pulp, strawberry syrup, etc. are added to the vat along with the inoculum before filling in to containers. However there is risk that the pulp may settle down at the bottom of the containers if the particles are big.

Dahi and Yoghurt - Commercial Production

It should be noted that these two products have many things in common; the difference being in flavour profile. While Dahi is produced with mixed cultures which produce acid and flavour both, the yoghurt is highly acidic in taste and therefore it is combined with added flavours and fruits. As a result of this commonalities, special arrangements could be made in a modern dairy to produce these cultured products. Such a specialty could be designed with the main intention of minimizing contamination from anything else. This requires receiving room to receive, measure and store milk and other raw materials; a culture preparation room; a laboratory; a dry store; a refrigerated store; a mix processing room; a fermentation room and a packaging hall. The fermentation room is very crucial and therefore kept isolated from other rooms and provided with supply of filtered air. The equipment and the various processes carried out in this plant would be more or less same as described earlier. However, the plastic cups and lids have more or less replaced the other methods of packing these days. Here again the packing machines of suitable speeds are available which can pack Dahi or Yoghurt in cups of different sizes at a speed upto 400 cups per minute.

Mishti Doi

This particular variety of Dahi is very popular in eastern parts of India and it is produced on a commercial scale in many dairies. This is a fermented milk product having creamish / brown colour with pleasant aroma. It is prepared from cow milk or mixed milk in which required amount of sugar is added during boiling. After cooling it is cultured and then poured in earthen pots and left undisturbed overnight. When a firm body is set, it is shifted to cold room. Mishti Doi is produced in low fat, medium fat and high fat varieties and sugar is added to the extent of 17-19%.

Lassi

Lassi of good quality should be of creamy white colour, free from extraneous matter, with pleasant and mild smell, clean sweet and sour taste without off flavour. A salty variety of Lassi is also liked by consumers.

Production

Lassi is produced from dahi prepared from toned milk or standardized milk with acidity of not more than 0.75% lactic acid. For every 100 litres of dahi, 16 kg sugar is added in dissolved form. The sugar solution is prepared by mixing every 16 kg sugar in 5 litres of water and heating it to 40°C when 100 gm of carboxymethyl cellulose (CMC) is added. The solution is heated to 75°C and then added into dahi and mixed properly.

This mixture is pasteurized at 80°C for 15 seconds and then homogenized on line at 60°C and 1500 psi pressure. The batch is then chilled below 10°C and it is ready for packing.

Lassi is packed in polyethylene pouches of 200ml. The specifications of the film should be the same as described under market milks. The pouches are stored in HDPE crates holding 10 litres (50 pouches) each. The crates are stored in cold store at 5°C and stacked in the same way as for market milk.

Chhas / Spiced Butter Milk

These fermented milk products (also Mattha), are popular all over India as summer time beverages.

Production

These varieties are produced by churning dahi of desired grade by traditional method while adding cold water. The aroma and mild sour taste are produced by fermentation by lactic acid bacteria.

In a dairy plant the spiced buttermilk is produced from dahi of suitable grade (either from toned or standardized milk) which is diluted by 3 times by addition of potable water. The spices are properly selected and dressed and washed with water and after cutting in small pieces; transferred to a mixer and ground to a pasty form. On weight basis Green Chillies (5%), Coriander leaves (2.5%); Ginger (2.5%); Table Salt (5%) and Jeera (roasted in oil and ground) as per taste are added in the mixture of curd and water. The entire mixture is allowed to stand for 45 minutes in a vat for absorption of flavour and aroma. Afterwards, the mixture is strained through muslin cloth and after organoleptic testing, the batch is considered as fit for packing.

Spiced butter milk is packed in polyethylene pouches of 200 ml. The specifications for film and the method of holding the pouches in HDPE crates and their storage in stacks in the cold store are the same as described for market milk and lassi.

Shrikhand

Shrikhand is a fermented milk product, sour and sweet in taste, which is traditionally popular in Maharashtra and Gujarat and thanks to the innovative efforts made by the NDDB, it has become popular in other parts of India as well. It forms a part of special meal and also served as dessert.

Production

In traditional method, cow milk or preferably buffalo milk is heated to boiling and then cooled to 30-35°C. Then it is inoculated with dahi (lactic culture), in proportion to 1% and allowed to set into curds. When the curd is firm, it is transferred on a clean muslin cloth which is tied up and kept hanging over a period of 10 to 12 hours to drain

off the whey. This yields an intermediary product called as Chakka or Maska. Generally the yield is 65% if the quantity of milk depending on its type. The chakka is mixed with sugar in proportion of 50 to 100 percent of the quantity of curd. Various additives are now added as per choice and variety. The commonly used substances are, Saffron; Almonds, Pistachio; Nutmeg, Cardamom; Mango pulp; Chaloli, Raisins, seasonal fruits, etc. This way about 1.5 to 2 kg of shrikhand is produced from 1 kg of Chakka.

Mechanised Production

The process of shrikhand manufacture has been mechanized which has made it possible to produce shrikhand of uniform composition. In the mechanized process the skim milk is heated to 90°C for 15 seconds in a HTST pasteurizer and cooled to 30°C and then inoculated with 0.25 – 0.50 percent dahi culture. After eight hours of incubation when the acidity of 0.8 to 1% (of lactic acid) is developed the curd is passed through basket centrifuge / quark separator whereby the whey is very efficiently removed from the curd. The capacity of quark separator may be as high as 2500 kg of curd per hour;

The shrikhand is produced by adding sugar in proportion to 80% of the amount of chakka and mixing in a Scraped Surface Heat Exchanger (SSHE). The required amount of plastic cream (80% fat) is also added along with sugar so as to give at least 8.5 percent fat in the finished production on dry matter basis. By using SSHE, the capacity to heat and mix chakka has been increased to 500 kg in 10 minutes.

The development of mechanised process has made it possible to prescribe the standards for shrikhand by the Bureau of Indian standards and also under the FSSA. According to these standards the shrikhand shall have minimum total solids by mass 58%, milk fat 8.5% by mass in dry matter; milk protein 10.5% by mass in dry matter; maximum acidity 1.4% (lactic acid), sucrose 72.5% by mass in dry matter and total ash 0.9% by mass in dry matter. The microbial standard is also prescribed as maximum coliform count of 10 cfu/gm and maximum yeast and mould count of 50 cfu/gm.

Shrikhand is packed in polystyrene cups of various shapes with capacity of 100 gm, 250 gm, 500 gm and 1 kg. A form fill seal machine can fill and pack upto 6000 cups per hour. The cups should be labeled with information regarding Name, Address, MMPO Regn no. of the dairy, the Product composition, Contents, Date of packing, Best before and MRP, etc. as per legal requirements.

The shelf life of shrikhand largely depends on the hygiene followed during its production. Improper handling of milk, chakka and other ingredients may lead to development of yeast mould and foreign organisms. At room temperature the shrikhand tends to spoil in 2-3 days. Under refrigerated condition at 4°C, it may stay for 40 days without spoilage. If it is properly pasteurized at 65°C for 10 minutes and subsequently frozen it can be kept in good condition for 6 to 12 months at the temperature of minus 18°C.

Fermented Milk Products in Dried Form

Some of the fermented milk products have been successfully spray dried. However, before deciding to produce them commercially, it may be prudent to survey the market conditions and consumer preferences for the fresh product. Two products are briefly described here:

Dahi Powder

The manufacturing process of dahi powder consists of the following steps:

1. Standardize the fat content of milk to 3-3.5%.
2. Condense the milk to 30% solids.
3. Add starter and allow the curd setting.
4. Drain the whey and collect the curd in muslin cloth.
5. Mix, homogenize and dry the curd in spray drier.

Dahi powder can be reconstituted with luke-warm water in the ratio of 1:3 by weight and cooled for about an hour in ice-cold water or refrigerator. The product yields dahi of uniform acceptable quality. The powder can also be used for preparation of Lassi by using powder and water in the ratio of 1:8. Dahi powder may have moisture 2 to 3%, milk fat 13 to 15% and total solids 97 to 98%.

Shrikhand Powder

The manufacturing process of shrikhand powder consists of the following steps:

1. Produce shrikhand by using traditional method as described above.
2. Add emulsifier sodium citrate in solution at the rate of 0.1 to 0.2% of the weight of the curd.
3. Add antioxidant (Embanox) at the rate of 0.02% of the weight of the curd.
4. Add warm water (60°C) to bring the moisture content of the curd to about 60%.
5. Homogenize the mix through a single state homogenizer at a pressure of 100 kg / cm².
6. Add sugar at the rate of 18 to 20% of the total weight of the curd.
7. Spray dry at 170°C inlet and 98°C outlet temperature of air to give the product moisture content of less than 2.5%.

After cooling, the shrikhand powder may be packed in 100 gm, 500 gm tins and sealed.

Shrikhand powder can be reconstituted with lukewarm water in the ratio of 2:3 by weight and the flavouring agents can be added as per choice. Shrikhand powder may have moisture 2 to 3%, milk fat 15 to 17%, sugar 40 to 45% and total solids 97 to 98%.

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Chapter 9

Coagulated Milk Products

Paneer and Chhana

These coagulated milk products provide good nutrition, convenience, safety and novelty of flavour and texture to the consumer. As a result, these products have become very popular, paneer being used as integral part of several north Indian cuisine and Chhana being used as a base to produce a wide variety of Bengali Sweets. These products are widely used all over India.

Paneer

Paneer, generally obtained from buffalo milk, has marble white appearance, a slightly spongy body, close-knit texture and a typical, sweetish acidic nutty flavour. It is produced by heat/acid coagulation of the casein component of standardized buffalo milk preferably with 6% fat or a level higher than 5% to yield a product corresponding to food standards. It can be made from cow milk or mixed milk but the results are likely to vary. Because of its high yield (upto 20%), and short time required in production, paneer offers a prospective business to the entrepreneur. As a result many private and cooperative dairies have started producing paneer.

Production of Paneer:

The paneer production involves the following steps:

- 1) **Heating and cooling of milk:** The standardized milk (min 5% fat, Fat-SNF ratio 1:1.65), is heated to 86°C in a conventional method for 5 minutes and then cooled to 76°C.
- 2) **Addition of coagulant:** A suitable coagulant (lime, alum or citric acid) is used. When citric acid is used the fresh solution of 1% strength is made in hot water at 76°C and it is slowly added to the milk. The milk is stirred vigorously till a clean whey is separated out.
- 3) **Drainage:** When the coagulation is complete, the stirring is stopped and the solids are allowed to settle for 5 minutes. The temperature of the whey is not allowed to go below 63°C and this is achieved by heating or cooling the contents in the vat by circulation of hot or cold water in the jacket. Afterwards, the contents are transferred over a muslin cloth to drain off the whey.
- 4) **Hooping and Pressing:** After draining off the whey, the solid mass is collected and filled in a rectangular hoop lined with muslin cloth. The hoop is just a

rectangular frame with both, top and bottom open (measurement 35 cm x 28 cm x 10 cmh). The top and bottom side of the hoop is covered with wooden planks which exactly fit into the hoop. Then pressure is applied on the top of the hoop by placing weight of 45 kg for about 15 minutes (i.e., 2 kg per sqcm approx). The pressed paneer is removed from the hoop and cut into pieces of appropriate size and immersed in chilled water at 4°C for 2 to 3 hours.

- 5) **Wiping and Packing:** The chilled paneer is removed from water and placed on wooden plank to allow loose water to drain for about 15 minutes. The pieces are then wiped and wrapped in parchment paper and kept in cold room at 10°C until released for sale.

Commercial Production

The process of commercial production of paneer has been developed by incorporating various equipment used in the manufacture of cheese, casein, etc. As a result the process is also standardized which begins from the fresh buffalo milk conforming to high microbiological quality and without any off flavour.

In the process, the standardized milk is heated in a plate heat exchanger from 4°C to 86°C and pumped into a water / steam jacketed cheese vat. Then the cold water is circulated in the jacket to allow the milk to cool to 76°C in about 10 minutes. In commercial process several coagulants have been tried so as to increase the yield or improve the quality. These include hydrochloric acid, phosphoric acid, lactic acid, calcium lactate, lemon, lime juice, vinegar etc. However, the addition of citric acid has been always the first choice. It is used in the concentration of 1% and held at 76°C at the time of addition into milk. It should be noted that the coagulation at higher temperature say 86°C, would result into decrease in moisture content of paneer. Further, the coagulation temperature of 76°C has been also found to yield paneer which has better frying quality in that it retains the shape and softness.

After coagulation, the milk is allowed to separate into curd and whey for 10 minutes. As the curd settles in the bottom of the cheese vat, the whey drainage valve is opened so that the whey flows into surge tank, partitioned by strainer to hold back fine curd particle. The whey thus collected is further pumped out, cooled to 4°C and stored elsewhere for further use.

The curd is now transferred to hoops lined with muslin cloth. Hoops in various capacity from 2 to 10 kg are available with perforation on all the sides. After filling the curd the top lid is placed and the pressure is applied from the top, which leads to draining of whey. Although addition of 2% salt at the time of hooping would extend the shelf life of panner, it should be noted that for culinary purpose the customers always prefer unsalted paneer.

For pressing, the paneer hoops are placed one above the other in layers upto 5. Then a

weight of 70 to 100 kg is applied from the top for about 15 minutes. As an alternative, the hydraulic press is also used to exert a pressure of 2 kg per sq. cm. After applying pressure, the wrapped blocks of paneer are removed from the hoops.

Cooling is done by immersing the paneer blocks in cold water at 4°C. After two hours, the paneer is ready for cutting and packing.

Packing of Paneer:

The shelf life of paneer very largely depends upon the sanitation followed during handling and packing of paneer. Therefore, the workers handling paneer should dip their hands in chlorine solution (with 100 mg chlorine per litre of water) each time when they start the handling. Further, the packing material should be such that it acts as oxygen and moisture barrier while preserving paneer at refrigeration temperature. The co-extruded laminates polyethylene sachets, wax-coated parchment paper and heat-induced shrink film provide all advantages and offer appeal and convenience to the consumers. Generally paneer is packed in 200 gm pouches of exact size thus leaving minimum air space inside. In fact, it is better to pack it in anaerobic condition which is possible with shrink-wrapping. It has been found that dipping the paneer in 5% solution of common salt, before packing can increase its shelf life to 3 weeks at 4°C. Whereas, heat sterilization of paneer cubes in sealed containers under pressure for 15 minutes can increase the shelf life upto 50 days.

The packages of paneer should carry a label giving details like Name and Address of the dairy, MMPO Reg. No., Contents: Paneer 200 gm, Batch No, Date of Packing, Best before in no of days at 5°C and the MRP inclusive of all taxes. During storage, transportation and with stockist, the paneer should be held at temperature below 5°C

Chhana

Chhana is a product obtained by acid precipitation of milk proteins with entrapped fat and water soluble components of milk viz., lactose, whey proteins, minerals and vitamins. Although it can be produced from skim milk, cow milk or buffalo milk; the chhana prepared from cow milk yields a softer and spongier product and hence preferred for making Bengali sweets. In contrast, the chhana made from buffalo milk is tougher and more compact.

Production:

Chhana is produced by heating the milk to boil in a large iron/stainless steel vessel and mixing old chhana whey as coagulant in hot milk while continuously stirring it. The coagulated mass is then transferred over clean muslin cloth held over the other vessel. In a still traditional method a small portion of heated milk is taken in a small vessel and coagulant is added into it, while stirring the milk. The coagulated mass is transferred each time over a muslin cloth. The muslin cloth is then tied and kept hanging to drain

off the whey. In the process of chhana manufacture, no pressure is applied to remove the whey.

Commercial production:

In a dairy plant, chhana is produced from a batch of milk which is boiled in a steam jacketed kettle while continuously stirring it. Thereafter, cold water is circulated in the jacket to reduce the temperature of milk to 85°C. Alternatively, the standardized milk is passed through plate heat exchanger and heated to 98°C and then transferred into a tank and cooled to 87°C. Then the coagulant is added in a thin stream just within a minute while stirring is continued. The most preferred coagulant is citric acid or lactic acid which is used in concentration of 0.5 to 1.5% at 70°C. When the whey is clear the chhana is transferred over muslin cloth and the whey is allowed to drain for about 30 minutes. By this method a batch of 100 litres milk standardized to 4% fat and 8.5% SNF yields about 15 kg of chhana.

Packing of Chhana:

Chhana, being an intermediary product is rather stored. At room temperature its quality deteriorates in a day or two. However, when stored at 4°C it remains good for 10 to 12 days. If Chhana is to be marketed then it should be packed in parchment paper, tin cans or cellulose/LDPE film bags. When stored in aluminium foil containers or LDPE bags it should be stored at 4°C.

Rasogolla

Rasogolla is one of the most favourite Bengali sweets as indicated by its popularity all over India. Although it originated from eastern India, now it is produced commercially more in Bikaner, Rajasthan and marketed in tins with shelf life of 3 months.

This being the most popular chhana based sweet, its production is briefly described here.

1. Freshly made soft cow milk chhana is preferred over any other type of chhana.
2. Chhana is kneaded to smooth paste and then small portion each with approximate weight of 8-10 gms are made.
3. Each portion is rolled manually, between the palms and ball like shape is given.
4. If buffalo milk chhana is used then it is kneaded with addition of wheat flour and small amount of baking powder.
5. The chhana balls are cooked in sugar syrup which is prepared by mixing three parts of sugar with two parts of water and one part of whey. The pH of this syrup has to be adjusted to 6.8 by using calcium hydroxide.
6. Chhana balls are dipped in the cooking syrup and it is boiled for 15 minutes. During cooking process, water and whey are added to maintain the concentration.

7. After cooking, the balls are transferred to a container with water held at 33°C. This leads to the development of proper texture and colour.
8. After the texture is developed the rasogolla balls are transferred again to sugar syrup in two stages. The first dipping is for about 2 hours in a syrup with 50-60 brix sugar followed by next dipping in a syrup with 40-50 brix sugar. It is important that the final concentration of sugar syrup should be 50% so that a proper balance in sugar concentration is reached inside as well as outside the rasogolla balls.
9. Rasogollas are then stored at 10°C.
10. Generally rasogollas (14 pieces) are packed in 1kg capacity lacquered tins. The empty tins are sterilized before packing and then filled with rasogollas, syrup and the permissible preservatives. Afterwards the lids are tightly sealed and the tins are allowed to stand in cold water for quick condensation of vapour inside and creation of small vacuumes.

By this process one kg of chhana would give an yield of 100 rasogollas and when sugar is drained they would weigh 2.5 kg. The other Bengali sweets made from chhana like Rasmalai, Raj bhog, Sandesh, etc., have shorter shelf life and hence their commercial production is limited.

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Chapter 10

Desiccated Milk Products

Khoa, Peda, Gulabjamun

Khoa

Khoa is a product obtained by rapid drying of milk of cow or buffalo or goat or sheep or a combination thereof with or without addition of milk solids. It occupies a major place as an intermediate base for production of a wide range of milk sweets. As a result some of its attributes are important for its acceptability by sweet manufacturers. Ideally the khoa should have a typical mildly cooked flavour like that of boiled milk and also soft uniform body with granular texture. The cow milk khoa should be pale yellow in colour whereas the buffalo milk khoa should be white and both should have a tinge of brown. Khoa is produced in three varieties which are specifically used for certain types of sweets. Dhap is a variety used for Gulabjaman, Pantua; Pindi is a variety used for Burfi and Peda; and Danedar is a variety used for Kalakand, Milk cake, etc. The Bureau of Indian standards has laid down specifications for these varieties as under.

Variety	% Total Solids Minimum	% Fat in dry matter, Minimum	% Ash in dry matter, Maximum	Acidity as % of lactic acid
Dhap	55	37	6	0.6
Pindi	65	37	6	0.8
Danedar	60	37	6	0.9

The average composition of khoa from cow milk is: moisture 25.6 percent, fat 25.9 percent, protein 19.2 percent, lactose 25.6 percent, ash 3.7 percent, and iron 139 p.p.m.; that from buffalo milk is: moisture 19.3 percent, fat 37.1 percent, protein 17.8 percent, lactose 22.1 percent, ash 3.7 percent and iron 125 p.p.m.

Production

Quality of Milk : For the manufacture of Khoa buffalo milk is preferable. It yields a product with soft, loose body and smooth granular texture, which is highly suitable for the preparation of Gulabjamun. The buffalo milk gives a greater out-turn than that from cow milk, the yield of khoa being 21.6 percent for the former and 18.3 percent for the latter. Khoa from cow milk has an undesirable, slightly hard, sticky body and sandy texture, and does not produce best quality sweetmeats. A lower level of fat in the milk results in hard and rubbery body and coarse texture whereas higher fat level improves the quality of khoa.

Traditional Method:

The traditional method of khoa making is simple as it needs just the following equipment.

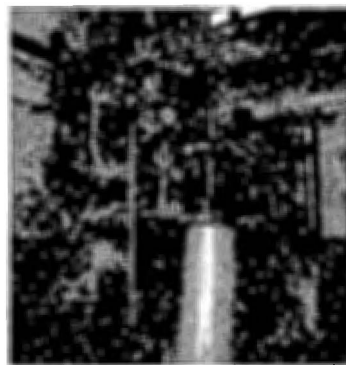
- i) **Karahi:** Karahi (made of iron) is a small, shallow, open round bottomed iron pan fitted with two small loop handles; weight 5 kg.; top diameter 40 cm; depth at center 12.5 cm.; total capacity 10 kg.
- ii) **Khunti:** It is an iron-stirrer; weight 0.5 kg.; length 65 cm.; width of flattened end 7.5 cm.
- iii) **Oven:** Charcoal-chulah; Diameter of firing area 32 cm; charcoal-holding capacity 2.5 kg (which makes a uniform layer of 12.5 cm. thickness)

While using this equipment khoa is produced in batches of 4 to 5 litres each. To have uniform quality the cow milk is adjusted to 4% fat and buffalo milk to 5% fat. Each batch of milk is boiled in a Karahi, placed over brisk (non-smoky) fire, and is stirred continuously with circular motion by the flattened end of an iron stirrer called khunti. During the operation all parts of the pan with which the milk comes in contact are lightly scraped. Constant evaporation of moisture takes place and the milk thickens progressively; at a certain stage, the thickened mass shows an abrupt change of colour, indicating occurrence of heat coagulation of the milk proteins. Vigorous stirring and desiccation is continued till the viscous product reaches a pasty consistency and begins to dry up. Very close attention is given at the later stages. The final product is ready when it shows sign of leaving the sides of the pan and sticking together so as to make pat formation possible. The khoa pat is invariably made after removing the pan off the fire, and by working the contents up and down. The finished product is in the form of small balls or circular pats of more or less uniform weight (0.5-0.75 kg).

The pindi variety of khoa requires heating of milk for a longer time to reduce the moisture content. For producing Danedar variety citric acid (about 0.1%) is added towards the last stage of heating. Finally the product is allowed to cool at room temperature. When cooled, it should not have visible water droplets or show signs of oozing of fat.

Continuous Khoa Making

In the conventional method using mild steel karahi there are chances of burning if the scraping is not effective and the process is slow and laborious. To overcome these drawbacks, a prototype equipment was designed and tried. This was a pan with steam jacket and mechanical scraper. The capacity of the equipment was 50 litres of milk at a time. Subsequently, a continuous khoa making equipment was designed where milk could be fed at one end and the khoa could be taken from the other end continuously. The equipment designed by Banerjee, Bagchi and others (1968) has the following essential parts:



- (i) A steam jacketed drum heater;
- (ii) Open steam jacketed pans;
- (iii) Scrapers; and
- (iv) Power drive for the scrapers.

The drum heater is fitted with rotary scraper. The milk is fed in the drum heater at one end and is partially concentrated and taken out from the other end. The rotary scraper works on the principle of centrifugal force and thus it gives an effective scraping and does not allow any burning on the surface. There are two open pans after the drum heater. The milk after concentrating to 30 to 35 percent in the drum heater is transferred to the open pans through a valve. These open pans are steam jacketed and have reciprocating scrapers. The milk is further concentrated in these pans to a total solids contents of 70 to 75 percent. The reciprocation scraper gives a perfect scraping action; thereby no burning would take place. The results achieved are as follows:

- In an 8 hours shift, 400 litres of milk can be converted into khoa at the rate of 50 litres of milk per hour. The job can be done by one man only under most hygienic conditions.
- The milk is not burnt during the process.
- The process is continuous. Thus it is a great saving in time and labour.

Fig. No – 10.1 shows Picture of Continuous Khoa Making Plant.

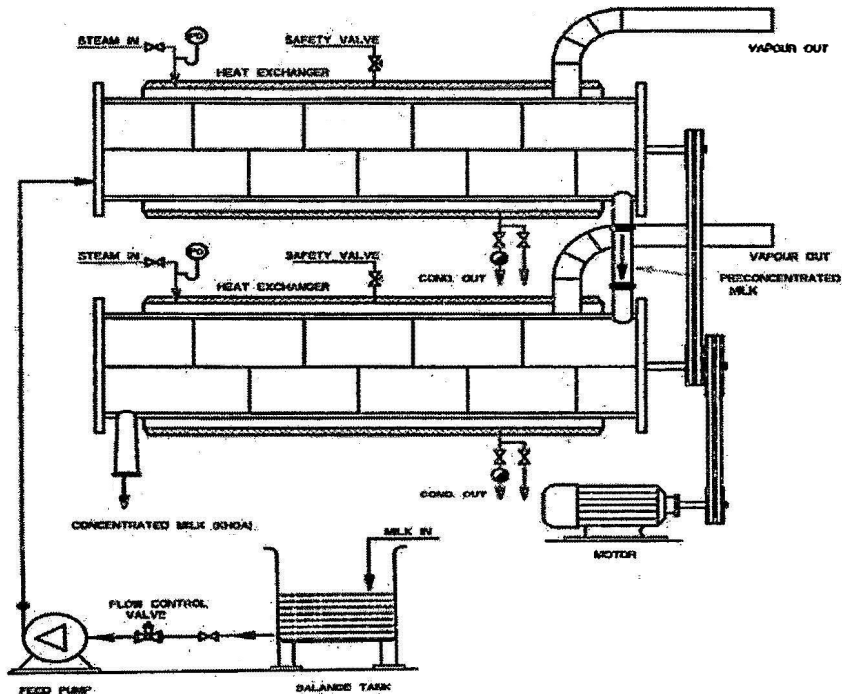


Fig. 10.1: Picture of Continuous Khoa Making Plant

Commercial Production:

Mechanised process has been developed for large scale commercial production of khoa. The Alfa-Laval group has developed a contherm scraped surface heat exchanger system wherein concentrated mass emerges from convap and then pumped through a holding tube which gives the final product with typical body and flavour.

The NDDDB has developed a system that provides a balance tank, a positive displacement pump and an inclined surface scraped heat exchanger. In the process the vacuum concentrated milk with 45 percent total solids is fed into heat exchanger barrel where it is continuously moved forward by the scraper agitator. The heat exchanger barrel is jacketed with segments so as to provide temperature gradients by controlling steam pressure. At the lower end of the barrel the temperature is kept high which keeps milk boiling. As it converts into semi solid mass it moves over a surface where temperature is lower. The final product coming out from the top of the barrel is allowed to cool at room temperature.

Packing and Storage:

Traditionally the khoa is packed in leaves and carried in bamboo baskets to the cities. To increase its shelf life it should be packed in polyethylene bags, parchment paper, laminated pouches or cans. Normally the khoa has shelf life of 2 to 3 days at room temperature. However, if handled carefully and stored under refrigeration, the shelf life can be enhanced upto 3 weeks.

Peda

Peda is a Khoa-based sweet, most frequently distributed on the festive and ceremonial occasions and enjoyed by all anywhere in India. In its simplest form, it is just a combination of khoa with ample amount of sugar and offered as a small rolled ball. However, many varieties are known as a set of tradition which is specific to a region like, Mathura, Dharwad, Rajkot, Satara, etc., and also as per additives like saffron, cashew, cocoa, etc. used in peda mix.

Production

Peda is produced by mixing three parts of Pindi variety of khoa with one part of sugar. The method involves breaking fresh khoa into bits and mixing it with ground sugar. The mixture is then heated in a Karahi and cooked on slow fire while stirring with iron stirrer (Khunti) till it turns into firm consistency. At this stage crushed cardamom, cashew nuts or saffron may be added, if desired. The contents are then poured in a clean tray and allowed to cool and set. The lot is now ready for conversion into Peda in round or flattened shapes by rolling small portions (of 15 to 25 grams) between the palms. Generally small amount of ghee is applied to the palms to avoid sticking. As a good manufacturing practice dies or moulds are preferred so as to reduce contamination which is unavoidable while using hands. If pistachio is to be used a sliced piece is applied on the top of each peda.

Commercial Production:

Peda production can be undertaken on a large scale in a modern dairy plant by using mechanized equipment. In the process, khoa having 72% total solids is heated to 60°C in a steam jacketed pan and then transferred to a planetary mixer. At this stage sugar, the crushed nuts, cardamom, etc. are added and mixed thoroughly. When it is ready, the mix is taken to a cold room to bring down the temperature to 5°C. When cooled, the mix is ready for conversion into pedas either by passing through a shaping machine or through a Rheon extruder.

Packing and Storage:

Pedas are Packed in cardboard boxes lined with greaseproof paper or butter paper. Generally, the boxes of exact size are used to hold exact number of pedas with the net weight of 250 gm, 500 gm or 1 kg; leaving no extra space inside. The method of modified atmosphere packing has been used by inserting 80% nitrogen and 20% carbon dioxide inside the multilayer transparent laminates. Also, under normal atmospheric environment the oxygen scavenger agents have been used to save pedas from oxidation of fat. These methods can help to extend the shelf life of peda from 15 to 90 days at room temperature and 1 to 6 months at 20°C. The boxes of peda should have printed matter giving Name & Address, MMPO Regn Number, Contents (Weight), Ingredients (*viz.*, Milk khoa, Sugar, Cardamom, etc.), Batch No, Date of manufacture, MRP and Best before (no of days), as per legal requirements.

Gulabjamun

Gulabjamun is one of the most popular khoa based sweets enjoyed by not only Indians of all age groups but also by all those who like Indian sweets universally. The round or cylindrically shaped Gulabjamun appears like a jamun fruit (Blackplum, *Eugenia jumbolana*), golden to dark brown in colour, with firm body and smooth texture and soaked in thick sugar syrup. A black variety is called as Kalajamun.

Production

Gulabjamun is produced by mixing 3 parts of dhap variety of khoa with one part of maida (fine wheat flour) and baking powder added upto 1% of khoa by weight. To this, water is added and the mixture is kneaded into dough of uniform consistency. The mass is now divided into small portions and each one rolled into round or cylindrical shape. Cardamom seeds are often added at the center. These are deep fried either in ghee or refined edible oil till they acquire brown or dark colour as desired and then released into sugar syrup prepared with 62.5% sugar solution flavoured with rose water.

Commercial Production

Many dairy plants in India and abroad have taken up production of Gulabjamun on a large scale. A mechanized process has been developed wherein khoa with 70% total

solids is mixed with maida in a planetary mixer and converted into dough. This is fed into a portioning machine which produces portion of 8 grams each. These portions are passed over a belt conveyor to a ball forming machine (similar to meat-ball rolling machine used in western conveyor). The balls are then passed over a conveyor to a frying machine wherein they are fried at 140°C temperature for 12 to 13 minutes. The fried balls are then transferred to a sugar syrup tank holding the syrup made with 62.5% sugar solution. The syrup is prepared beforehand in a kettle and after straining it is transferred to the sugar syrup tank. The Gulabjaman balls are allowed to soak in the syrup for 2 to 3 hours during which they swell and each ball doubles in weight.

Packing and Storage

Gulabjamun is packed in plastic containers with adequate quantity of syrup. The sealed containers are stored under refrigeration. The Gulabjamuns are also canned which enhances the shelf life to six months at room temperature. The container should have printed matter as per the details mentioned under packing of Peda.

Gulabjamun Mix

Gulabjamun mix is a ready to make preparation which is very popular with housewives who want to make Gulabjamun in their own kitchen. Several modern dairy plants are producing this item while using milk powder as the base which provides longer shelf-life to the mix. The formula is generally as under:

Roller-dried Skim milk powder 43.5%

Maida 25%

Samolina 15%

Butter fat / Hydrogenated fat 15%

Baking Powder 1.5%

While mixing these ingredients it is ensured that the fat portion is mixed thoroughly after melting it.

Packing and Storage

Gulabjamun mix is packed in laminated pouches. The pouches should have printed matter as per the details mentioned under packing of Peda. The pouches can be stored at room temperature with shelf life of more than 6 months. While making Gulabjamun, water is added to the extent of 50% of the weight of the mix and the dough is made.

Chapter 11

Mechanization of Manufacture of Traditional Dairy Products

Introduction

India today produces about 120 million tons of milk per annum. India is the largest milk producing country in the world. Milk and milk products constitute the largest gross agriculture produce of the country. The value of output from dairy sector was Rs 262214 crore during 2010-11. A significant amount of milk produced in India has been traditionally converted into a variety of sweets. The practice seems to have originated because of staggered production in remote areas, regional / seasonal surpluses, difficulties in transport / marketing and perishable nature of milk.

Milk produced in excess of the daily requirement for direct consumption is traditionally converted into various dairy products with longer shelf life. The nature of product manufactured depended upon the shelf life desired. The products like Dahi were obtained by fermentation of milk and extended the shelf life of milk by a day or two. For intermediate shelf life, products like Makkhan (butter), Khoa, and Chhanna were manufactured. In case longer shelf life was desired, products like ghee were manufactured. Most of these products acted as a base for the production of more sophisticated and more popular sweets like Shrikhand, Burfi, Gulabjaman, Peda, Rasgulla, Sandesh, etc.

In spite of the fact that the dairy industry has made rapid strides in the last 3-4 decades, the methods of manufacture of the traditional products have remained essentially unchanged except for a few isolated products. Most of the developments in the dairy sector in India have been directed towards manufacture of western dairy products for which equipment were readily available from industrially advanced countries.

With the increase in availability of liquid milk, development of more competition for the western type dairy products and improvement in per capita income after independence, there is an increased pressure for restructuring of the indigenous milk based sweets industry. The organized sector has started showing keen interest in processes and equipment for large scale manufacture of these products. Any innovation which can enable the organized sector to manufacture and market indigenous milk sweets on industrial scale can have far reaching impact on the dairy industry as well as on the social and economic condition of milk producers in the country.

Fig. No - 11.1: Shows Flow Chart for Conversion of Milk into Traditional Dairy Products

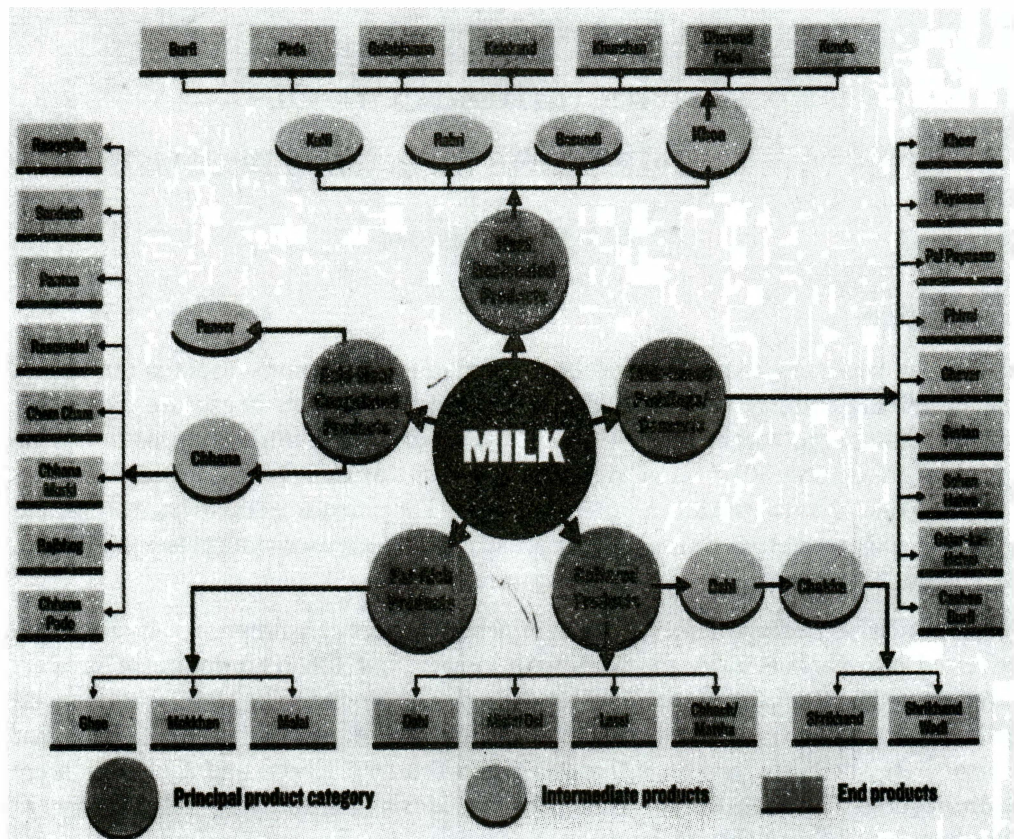


Fig. 11.1 Flow Chart for Conversion of Milk into Traditional Dairy Products

Source: Technology of Indian Milk Products A Dairy India Publication, 2002 Delhi, 110092

The indigenous milk products of India can be broadly classified into the following three categories, depending upon the method used for their manufacture:-

Condensed (Heat desiccated) Products:- Khoa, Burfi, Gulabjaman, Peda etc.

Cultured Products:- Dahi, Makkhan, Chhas, Lassi, Shrikhand, etc.

Acid Precipitated Products:- Paneer, Chhana, Sandesh, Pantooa, Rasgulla etc.

A flow diagram for conversion of Milk into Traditional Indian Dairy Products is shown in Fig. No – 11.2.

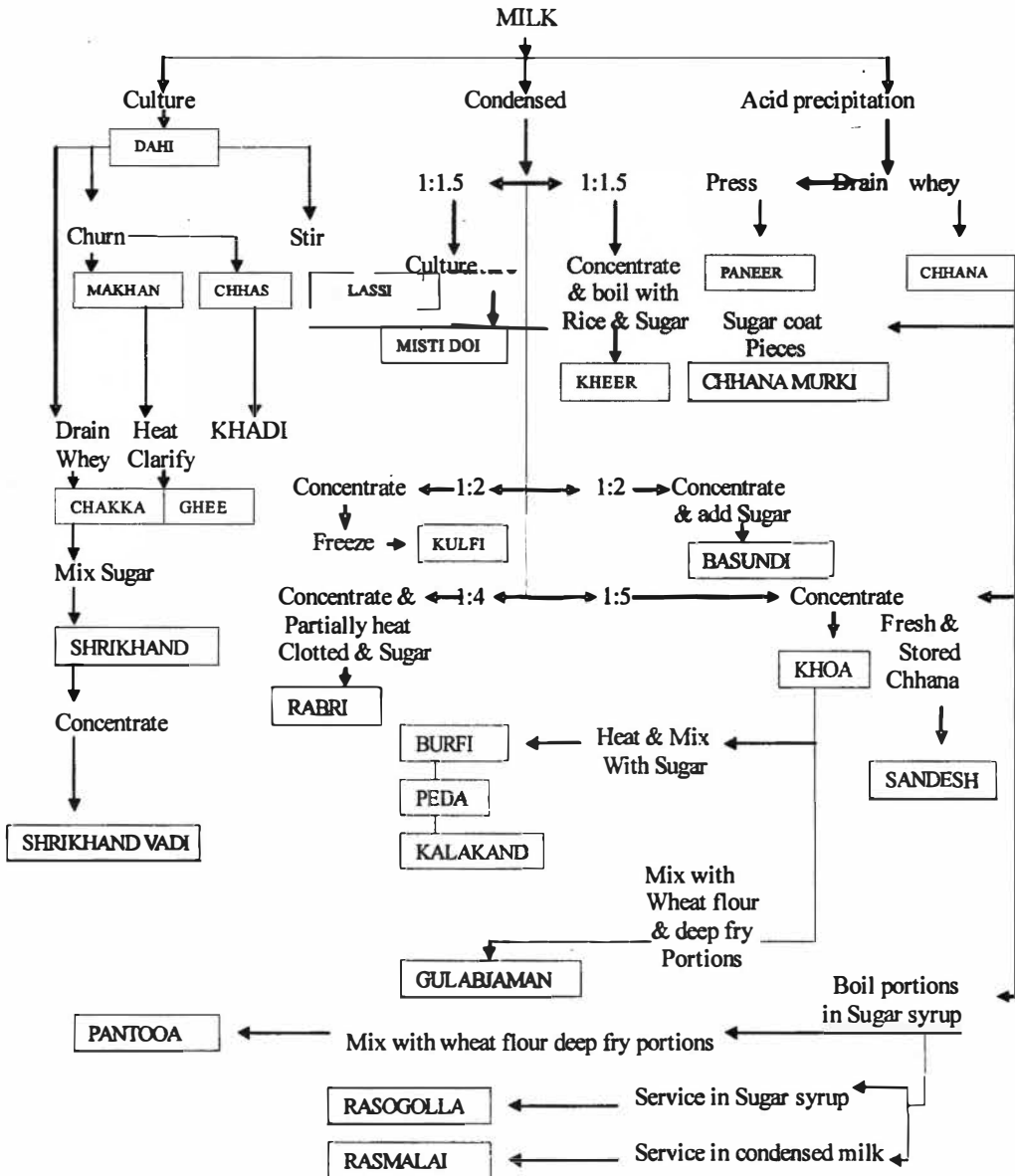


Fig 11.2 : Flow Diagram for Conversion of Milk into Traditional Indian Dairy Products

1. CHHANA

A process has been developed for the mechanized production of Chhana at IIT, Kharagpur involving continuous acid coagulation of milk. The process involves indirect heating of milk in a helical tube heat exchanger to 95°C followed by cooling to 70°C. Citric acid heated to 70°C employing U type heat exchanger, is continuously mixed in a vertical tube where the milk -acid mixture moves upwards. The residence time is so controlled as to permit complete coagulation of milk. Thereafter coagulum (Chhana) and whey are separated in a continuous flow employing a double walled basket centrifuge. Chhana so prepared may be chilled to 4°C by directly spraying chilled water on the layer of chhana.

Fig No – 11.3 Shows Flow-Chart for Chhana Manufacture from Cow's Milk.

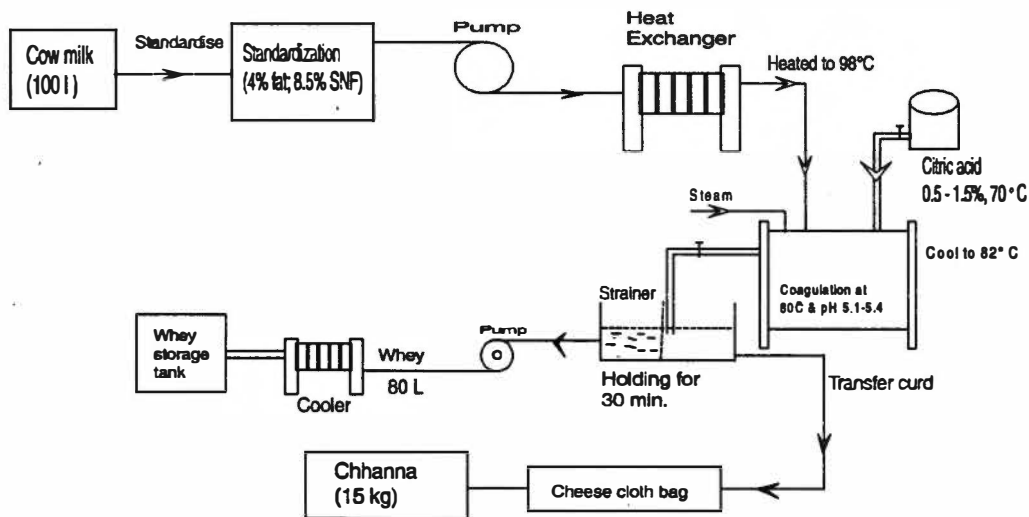


Fig. 11.3 : Flow Chart for Manufacturing Chhana from Cow's Milk.

2. PANEER

A considerable amount of research and development work has been conducted on the optimization of the process for manufacture of Paneer. The paneer process is illustrated in Fig. No – 11.4.

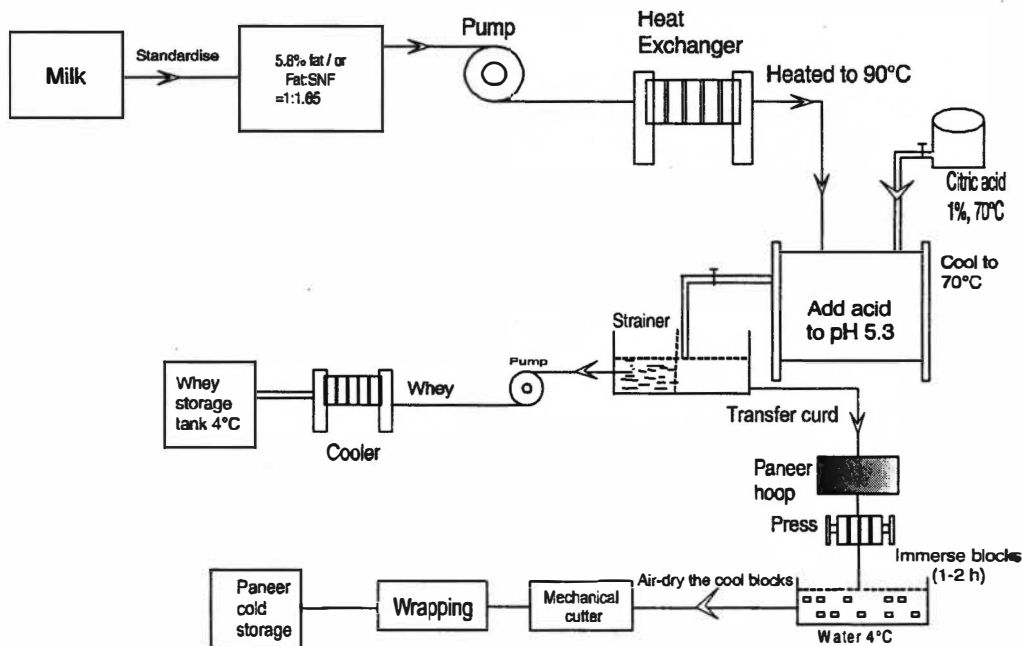


Fig. 11.4: Industrial Process for Manufacturing Paneer.

3. Mishti Doi

Mishti Doi is a highly nutritious, palatable, sweetened, fermented milk product available generally as a set curd product. Mishti Doi is very popular in the Eastern part of India especially in the state of West Bengal.

The traditional method for manufacture of mishti doi comprises various steps viz., Preparation of milk concentrate with or without addition of starch, colouring and flavouring the concentrate with burnt sugar, inoculating the previous day's product, dispensing the cultured mix in earthen bowls, incubating these overnight by keeping the bowls near a chulha without any control over the incubation temperature, acidity development etc.

NDDB has developed an improved and hygienic industrial scale process for preparing Mishti Doi which includes the process of making "Base-Mix" with predetermined level of milk fat, milk solids not fat, sugar and caramel; heating the base-mix to 90°C; cooling down to 42-45°C; inoculating with a starter culture; filling in the polystyrene cups; sealing; incubating at 42°C till the desired level of acidity is reached. The product is immediately transferred to the cold store.

4. RASOGOLLA

Rasogolla is the undisputed king not only of Bengali sweets but of all Indian sweets. This soft succulent ball of chhana (cottage cheese) soaked in sugar syrup has delighted the taste buds of millions of connoisseurs for more than hundred years. Its popularity has spread beyond the Indian shores to captivate epicureans the world over. Fig. No – 11.5 shows Flow diagram for Rasogolla Manufacturing

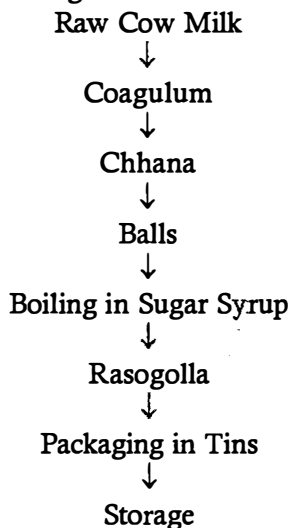


Fig. 11.5: Flow diagram for Rasogolla Manufacturing

Manufacturing Process

Rasogolla is prepared from cow milk which is processed and standardized to 4.0% and 8.5% SNF. Rasogulla is prepared from soft, freshly made cow milk chhana. Chhana is manually kneaded to a smooth paste. The paste is portioned and rolled between palms to form balls of about 15 mm diameter and around 8-10 grams in weight. Each ball should have a smooth surface with no cracks. To prepare cooking medium dissolve sugar in water (1:4) and boil the solution. During this process, add little milk ladle out the scum to obtain a clean syrup. Keep this in a steam kettle in which the chhana balls are to be cooked. Rasogulla balls are dipped in the cooking medium and are cooked for 15 minutes. After cooking the balls are transferred to a container with water at 30-35°C for their texture stabilization and colour improvement.

Packaging and Shelf Life

The tin containers of 1 kg and 1/2 kg are used for packaging rasogollas. The empty containers are first sterilized in hot air inside a closed chamber. Rasogolla balls with hot sugar syrup and permissible preservative are filled in containers and seaming tightly seals the lid. These containers are kept in a tub containing chilled water to create partial vacuum by quick condensation of vapors inside the container. The shelf life has been reported to be around 3 months in tin containers.

5. GULABJAMUN

Gulabjamun is a nationally popular khoa-based sweet. Originally, it is made with khoa and maida (flour). As it looked like monsoon fruit, jaman and was flavoured with rose water it got its name of Gulabjamun. It is usually consumed hot. The gourmet version of gulabjamun has centre-cored honey with pistachio and cardamom seeds and is preserved in kesar (saffron) syrup.

Manufacturing Process

Gulabjamun is prepared from buffalo milk which is processed and prepared in khoa. Khoa with 60-70 percent total solids is mixed in a planetary mixer with 19-22 percent of maida and leavening agent (baking powder). The dough is divided into 8 gram portions and transported to the ball forming machine. Then the balls are shaped like a cylinder and are carried to the frying system containing oil at a temperature of 140°C. After frying the balls are soaked in 62.5 percent sugar syrup solution. The Gulabjamuns are then packed in plastic containers and an appropriate amount of hot syrup is added. Lids are applied on the cups and subsequently sealed. Packaged gulabjamuns are stored under refrigerated conditions. Canned gulabjamuns are stored at room temperature. The shelf life of canned gulabjamun is about six months at room temperature. Fig. No – 11.6 shows Flow Diagram for the Gulabjamun Manufacturing

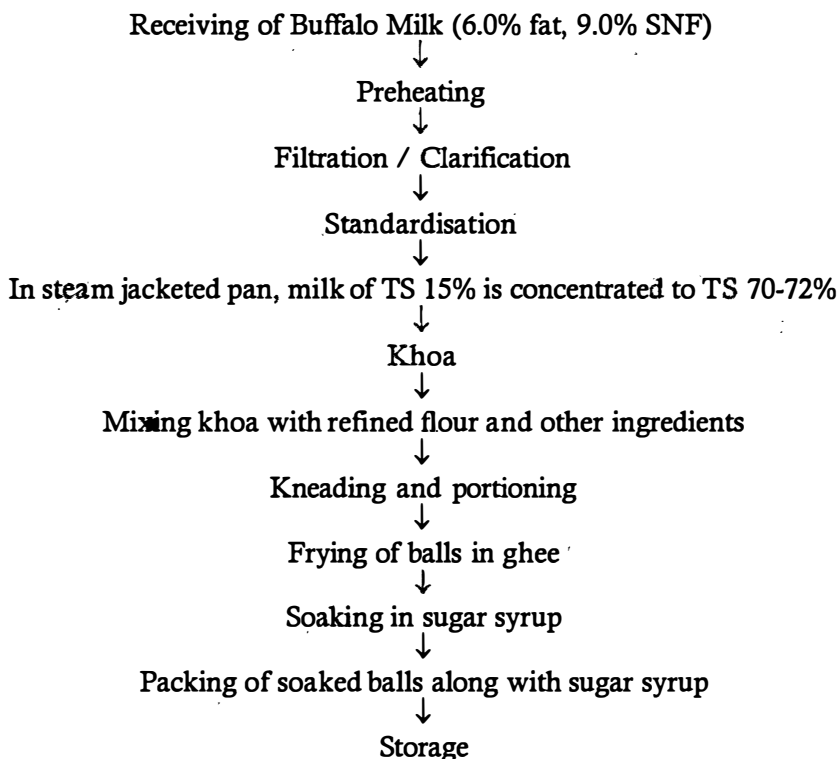


Fig. 11.6 Flow Diagram for Gulabjamun Manufacturing

Composition of Gulabjamun

The composition of gulabjamun on a drained weight basis is: fat (10%), protein (6%), sugar (42%) and other solids (14%). Acidity of the syrup for Gulabjamun should not exceed 6 ml of 0.1 N sodium hydroxide, needed to neutralize 100 ml of the syrup. Concentrate of the syrup should be maintained at 62.4° Brix.

6. SHRIKHAND

Shrikhand is a *dahi*-based product. The dahi / curd is partially strained through a muslin cloth to remove the whey and thus produce a solid mass called chakka (basic ingredient for shrikhand). This chakka is mixed with the required amount of sugar, spice or nuts or fruit pulp to make different varieties of shrikhand.

A fully mechanized/continuous process has been developed for industrial scale of production of Shrikhand.

Preparation of Curd: Skim milk (9 percent SNF, 0.05 percent fat) is heated to 90°C for 10 sec. in a HTST pasteurizer, cooled to 30°C and inoculated with 0.25-0.50 percent dahi culture of mixed strains. After 8 hrs of incubation period (0.8 percent as lactic acid), curd is ready for further processing.

Preparation of chakka: Chakka is prepared by separating the whey from dahi employing a 28" dia basket centrifuge at 1100 rpm, which permits 80 kg of curd per hour. Alternatively, a horizontal desludging centrifuge (Westphalia SDA 230) may also be satisfactorily employed for separating whey from curd.

Preparation of Shrikhand from Chakka: In the process described here, Shrikhand is prepared by adding sugar at the rate of 80 percent of the amount of chakka and mixed in a planetary mixer. Predetermined amount of plastic cream (80 percent fat) is added along with sugar to chakka so as to give at least 8.5 percent fat in the finished product.

Mixing of Maska with Cream and Sugar: The mixing capacity in the earlier process was limited due to use of planetary mixer, which could handle up to 40 kg/batch. By replacing with a scraped surface heat exchanger (SSHE), handling per batch may be increased up to 500 kg in 10 min. Two such mixers may be installed in the line to facilitate continuity in production. When one mixture was used for production, the other was emptied to Shrikhand cooling tank.

Packaging of Shrikhand: In the earlier process, the use of pre-formed polystyrene cups for packing Shrikhand limited the capacity to 1000 cups/hour. By employing a 'Form-fill-seal' machine up to 6000 cups can be filled / packed per hour.

Chapter 12

Cheese, Casein and Whey

CHEESE

1. Definition :

'Cheese is the fresh or matured solid or semi-solid product obtained by coagulating milk, skimmed milk, partially skimmed milk, cream, whey cream, or buttermilk or any combination of these materials through the action of rennet or other suitable coagulating agents, and by partially draining the whey resulting from such coagulation.

2. Classification:

"Variety is the spice of life", so we have hundreds of cheese varieties developed through the efforts of cheese makers over many centuries. This is not surprising when one considers so many variables or combinations there of that may be applied to the cheese making process. These variables include:

1. Milk (cow, buffalo, sheep, goat, etc.).
2. Coagulant (enzyme, acid).
3. Curd treatments (cutting, warming, pressing, etc.).
4. Ripening agents (microbes, enzymes).
5. Ripening conditions (temperature, humidity).

1.1 Terminology for the Classification of Cheese

- i. Cured or ripened cheese:* It is a cheese which is not ready for consumption shortly after manufacture but which must be held for such time, temperature, and under such other conditions as will result in the necessary biochemical and physical changes characterizing the cheese.
- ii. Mould cured or ripened cheese :* It is a cured cheese in which the curing has been accomplished primarily by the development of characteristic mould growth throughout the interior and/or on the surface of the cheese.
- iii. Uncured, unripened or fresh cheese:* It is a cheese that is ready for consumption shortly after manufacture.

3. Composition of Cheese

Typical composition of Cheddar cheese made from cow milk, buffalo milk and mixed milk (with and without half- whey salting) is given in **Table 12.1**. The average proximate

composition of Cheddar Cheese & Mozzarella Cheese made from buffalo and cow milks is presented in Table No - 12.2

Table 12.1: Composition of Cheddar Cheese

Constituent	Cheese Type				
	Cow Milk	Buffalo milk		Mixed Milk	
		Untreated	Half-whey salted	Untreated	Half-whey salted
Moisture (%)	37.00	34.75	37.77	36.61	38.46
MFFS (%)	54.41	52.12	55.29	54.77	56.97
Fat (%)	32.00	33.33	31.67	33.17	32.50
FDM (%)	50.79	51.07	50.89	52.31	52.80
Protein (%)	25.00	25.32	24.57	23.39	22.58
Lactose (CHO) (%)	2.10	1.94	2.28	2.51	2.82
Salt (%)	1.50	1.37	1.40	1.82	1.48
Salt-in-moisture (%)	4.05	3.93	3.69	4.97	3.86
Ash (%)	3.70	4.66	3.71	4.59	3.64
Calcium (%)	0.725	0.836	0.522	0.815	0.555
Phosphorus (%)	0.495	0.484	0.411	0.520	0.470
pH	5.2-5.4	5.21	5.17	5.41	5.12

(MFFS) moisture-in-fat free substances ; (FDM) fat-in-dry matter

Source : Prateek Kumar (1995)

Table 12.2: Proximate Composition of Mozzarella Cheese

Cheese Type	Moisture (%)	Fat (%)	FDM (%)	Protein (%)	Salt (%)	pH
Buffalo Milk Mozzarella :						
Milk adjusted to 0.7:1.0 C/F ratio ¹	49.56	24.15	47.89	22.88	0.97	5.23
Milk adjusted to 3% fat ²	54.95	16.46	36.0	23.91	1.28	5.5
Milk adjusted to 6% fat ²	51.53	25.17	51.0	18.73	1.26	5.6
Milk adjusted to 4% fat ³	49.81	23.05	45.92	22.35	1.56	0.67+
Cow Milk Mozzarella :						
Milk adjusted to 4% fat ³	50.30	24.80	49.00	20.31	1.72	0.73+
Low fat, low moisture ⁴	51.80	11.1	23.1	-	-	5.50
Low fat, high moisture ⁴	57.40	9.5	22.3	-	-	5.31
High fat, low moisture ⁴	47.30	25.1	47.6	-	-	5.39
High fat, high moisture ⁴	52.20	21.0	43.9	-	-	5.23
Mozzarella (3% fat milk) ⁵	53.60	18.0	38.0	22.1	0.7-1.0	5.2
Part-skim Mozzarella (2% fat milk) ⁵	57.20	13.5	31.0	21.2	0.7-1.0	5.2
Part-skim Mozzarella (1% fat milk) ⁵	57.30	8.0	18.0	25.7	0.7-1.0	5.2
Low moisture Mozzarella ⁵	47.00	23.7	44.0	25.0	0.7-1.0	5.2
Low moisture UF Mozzarella ⁶	45.70	20.50	37.80	26.40	4.20 (ash)	-

Source : 1-Ravi Sundar (1986); 2-Patel (1984); 3-Ghosh and Singh (1990); 4-Tunick et al. (1991); 5-Kosikowski (1982); 6-Covacevich and Kosikowski (1978); + = Acidity (% lactic acid)

3.1 Compositional Standards for Cheese in India

3.1.1 FSSAI Specification

(a) Cheese, hard: The product obtained by draining after coagulation of milk with a harmless milk coagulation agent under the influence of harmless bacterial cultures. It shall not contain any ingredients not found in milk, except coagulating agent, sodium chloride, calcium chloride (anhydrous salt) not exceeding 0.02 percent by weight, annatto or carotene colour and may contain emulsifiers and/or stabilizers, namely citric acid, sodium citrate or sodium salts of orthophosphoric acid and polyphosphoric acid (as linear phosphate), not exceeding 0.2 percent by weight. Wax used for covering the outer surface shall not contain anything harmful to health. In case the wax is coloured, only permitted food colour shall be used. Hard cheese shall contain not more than 43.0 percent moisture and not less than 42.0 percent milk fat of the dry matter. Hard cheese may contain up to 3000 parts per million sorbic acid or its sodium, potassium or calcium salts calculated as sorbic acid, and/ or 12.5 parts per million nisin either singly or in combination. Natamycin may be used for surface treatment only; subject to the following conditions, namely (i) maximum level of application shall not exceed 2 mg/dm³ of cheese surface, (ii) the penetration depth shall not exceed 2 mm and (iii) the maximum residue level in the finished product shall not exceed 1 mg/ dm³.

(b) Processed cheese: The product obtained by heating one or more types of hard cheese with permitted emulsifiers and/or stabilizers, namely citric acid, sodium citrate, sodium salts of orthophosphoric acid and polyphosphoric acid (as linear phosphate) with or without added condiments; and acidifying agents, namely vinegar, lactic acid, acetic acid, citric acid and phosphoric acid. Processed cheese may contain not more than 4.0 percent of anhydrous permitted emulsifiers and/or stabilizers, provided that the content of anhydrous inorganic agent shall in no case exceed 3.0 percent of the finished product. It shall not contain more than 47.0 percent moisture. Processed cheese chiplets (packed sliced cheese) when sold in a package other than tin, shall not contain more than 50% moisture. The milk fat content shall not be less than 40% of the dry matter. Processed cheese may contain up to 3000 parts per million sorbic acid or its sodium, potassium or calcium salts (calculated as sorbic acid) and / or 12.5 parts per million nisin either singly or in combination. It may contain calcium chloride (anhydrous) not exceeding 0.02% by weight.

(c) Processed cheese spread: A product obtained by comminuting and mixing one or more types of cheeses into a homogenous plastic mass with the aid of heat. It may not contain butter, cream, butteroil, milk, skimmed milk, milk powder, cheese whey, sweet butter milk or one or more of these from which part of water has been removed. It may contain permitted emulsifying and stabilizing agents. It may also contain one or more of the sodium/potassium salts of citric acid, phosphoric acid, tartaric acid, lactic acid

in such quantities that mass of the solids of such emulsifying agents is not more than 4 percent of mass of the processed cheese spread. It may contain sequestering and buffering agents, namely, lactic acid, acetic acid, citric acid and phosphoric acid. It may contain vegetable colouring matter such as annatto, carotene, permitted flavouring agents and milk coagulating enzymes with or without purified calcium chloride (anhydrous salt) and sodium citrate not exceeding 0.02 percent may be added. It may contain natural sweetening agents, namely, sugar, dextrose, cane sugar, corn syrup, honey, corn syrup solids, maltose, malt syrup and hydrolysed lactose in a quantity necessary for seasoning, and spices and condiments. It may contain sodium chloride not exceeding 3 percent by weight. Processed cheese spread may contain up to 3000 parts per million sorbic acid or its sodium, potassium or calcium salts (calculated as sorbic acid) and/or 12.5 parts per million nisin. It shall not contain more than 60 percent moisture and milk fat content (on dry basis) shall not be less than 40 percent by weight. **Table No – 12.3** shows Specifications for Hard Cheese, Processed Cheese, Processed Cheese Spread and Soft Cheese.

Table 12.3: Specifications for Hard, Processed, Processed Spread and Soft Cheese

<i>Characteristic</i>	<i>Cheese Type</i>				
	<i>Hard</i>	<i>Processed</i>	<i>Processed spread</i>	<i>Soft cheese Milk</i>	<i>Soft cheese Skim milk</i>
• Moisture, % by mass	43.0 (Max.)	47.0 (Max.)	60.0 (Max.)	48 to 70	48 to 70
• Milk fat (on dry basis), % by mass	42.0 (Min.)	40.0 (Min.)	40.0 (Min.)	50.0 (Min.)	13.0 (Max.)
• Salt (added NaCl), % by mass	3.0 (Max.)	3.0 (Max.)	3.0 (Max.)	Optional	Optional

Source: Indian Standard (IS: 2785, 1979)

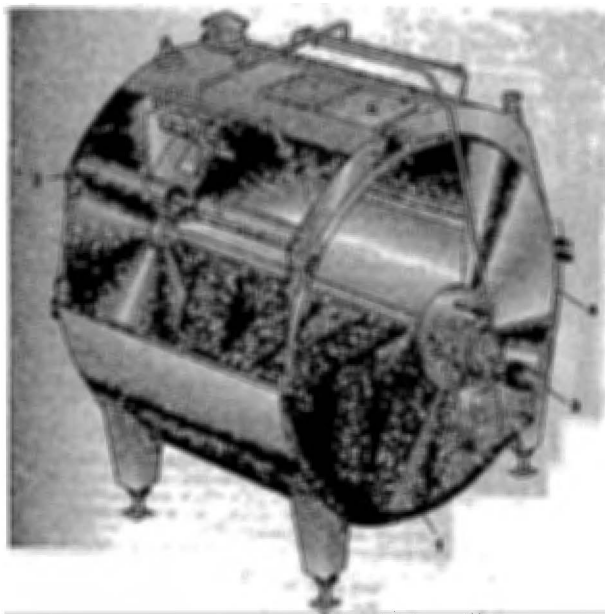
4. Types Of Cheese

- I) Cheddar Cheese;
- II) Processed Cheddar Cheese;
- III) Mozzarella Cheese.

(I) Cheddar Cheese:

Cheddar cheese is named after the cheddar Village in U.K., where it was first made and also after the unique step of 'Cheddaring' followed in its manufacture. It is a hard, close textured, bacterial ripened rennet cheese. The shape of Cheddar cheese may be cylindrical or rectangular or square. Its colour varies from white to orange but usually it is butter yellow. It has firm and waxy body; its texture is close-a few irregular holes are acceptable. Flavour of ripe cheese is acid or slight acid with pleasant nutty note.

Fig. No - 12.1 shows Picture of Horizontal Enclosed Cheese Tank with Combined Stirring and Cutting Tools Hoisted Whey Drainage System.



1. Combined cutting & stirring tools
2. Strainer for whey drainage
3. Frequency controlled motor drive
4. Jacket for heating
5. Manhole
6. CIP nozzle

Fig. 12.1: Horizontal Enclosed Cheese Tank with Combined Stirring and Cutting Tools Hoisted Whey Drainage System

Its normal pH is 5.0-5.3. Typical process protocols for manufacture of Cheddar cheese from buffalo and cow milks are given in Fig. No - 12.2 and Fig. No - 12.6, while various equipment used in the manufacture of cheese are given in figure No. 12.3 to 12.5 and 12.8

The recipe for buffalo milk Cheddar cheese is based on the half-whey salting technique, suggested by Czulak (1964). The technique is one that is most widely used in commercial practice. The basis of this technique is that addition of common salt (NaCl) during cooking after draining half of the whey permits replacement of calcium with sodium in paracaseinate complex through ion exchange phenomenon thus giving cheese, higher moisture retention, improved body and texture as well as faster rate of ripening.

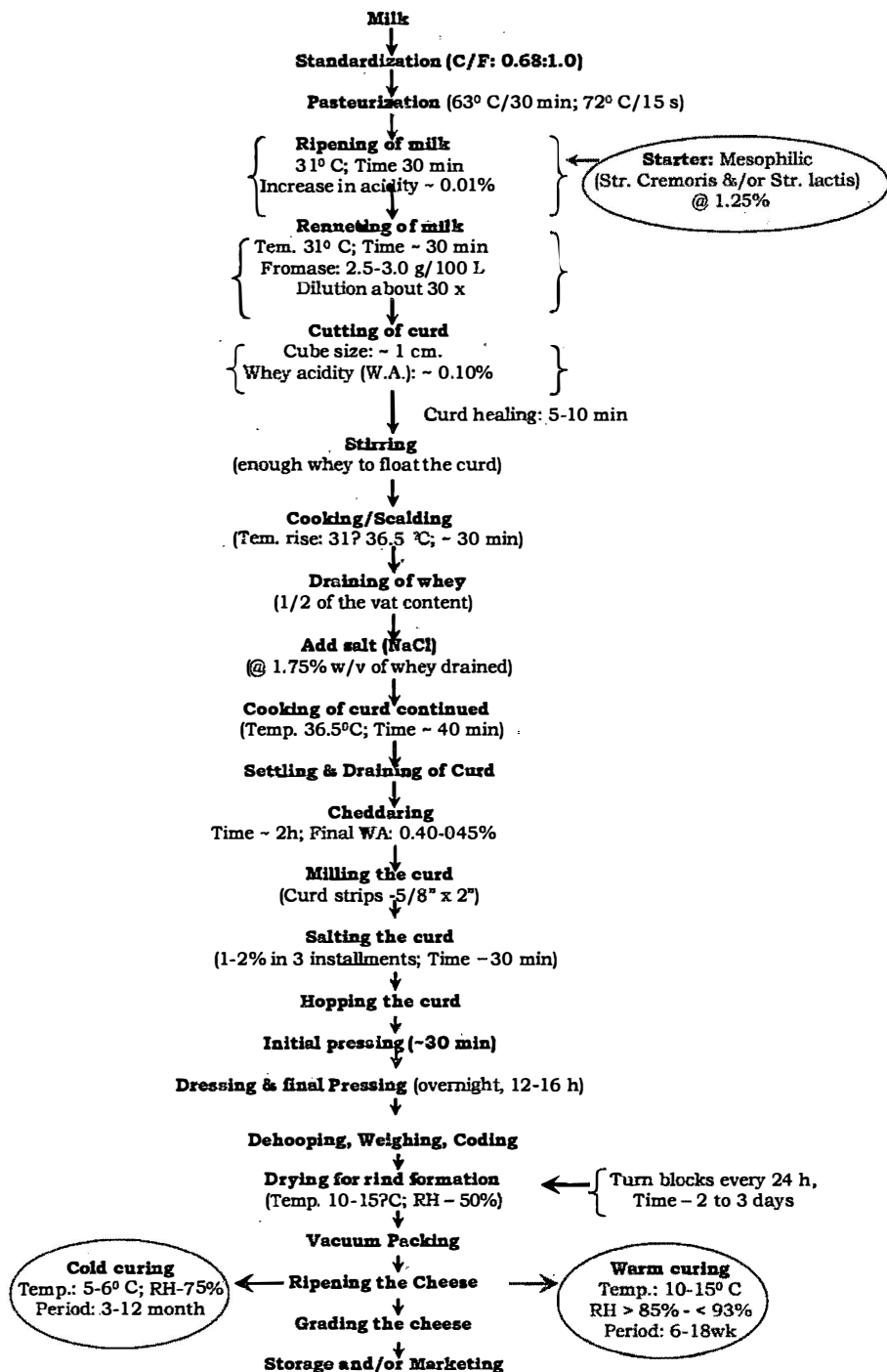


Fig. No 12.2 : Flow Diagram for Cheddar Cheese Manufacture from Buffalo Milk by Half-Whey Salting Technique

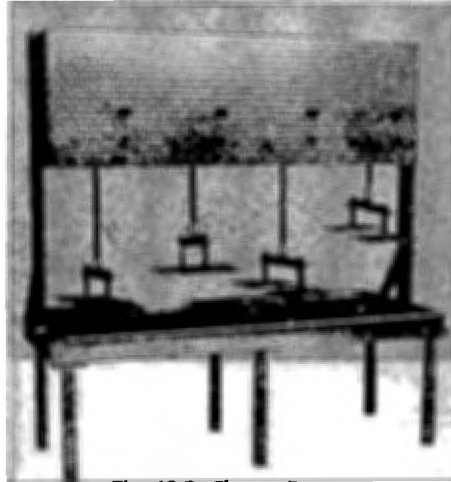


Fig. 12.3: Cheese Press

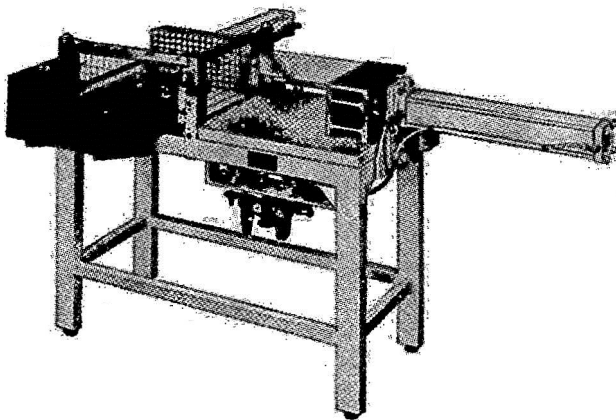


Fig. 12.4: Cheese Portioning Machine

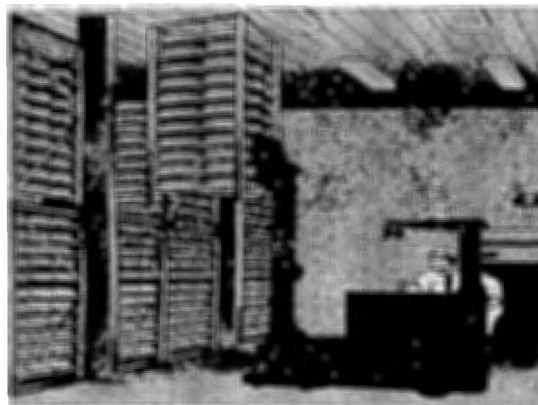


Fig. 12.5: Cheese Storage Using Pallets

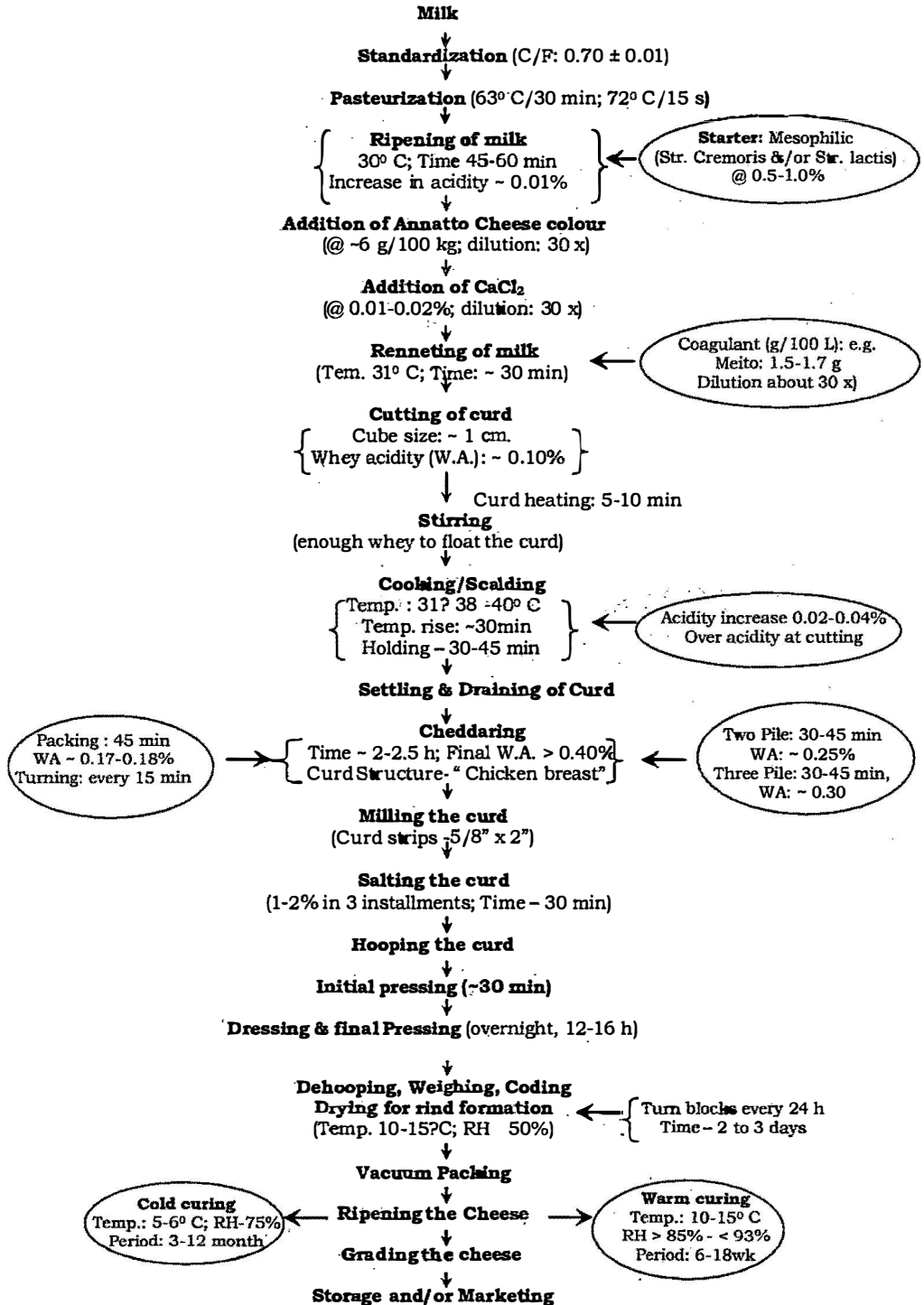


Fig. 12.6: Flow Diagram for manufacture of Cheddar Cheese from Cow milk

(II) Processed Cheddar Cheese:

The Process protocols for manufacture of processed cheese is given in **Fig. No. 12.7**

Selection of Natural Cheese

Criteria : Type, Flavour, maturity, texture and pH

Avoid: Cheese with microbial defects: spore-formers, gas producers and pathogens.

Computation of Ingredients

For a given composition of finished product, it is based on material balance (Fat and DM of raw cheese, blend constituents, added water, steam condensate).

Blending

Proportion of natural cheese used: Processed cheese (block type): 70-75% mild, 25-30% semi mature to mature; Processed cheese (slice type): 30-40% young, 50-60% mild, 10% mature or 55% young, 35% semi-mature and 10% mature. Other dairy and non dairy ingredients as per type of finished cheese.



Addition of Emulsifying Salts(s)

Type & amount based on: (1) Dry matter, fat, protein, Ca^{++} & pH of natural cheese, (2) Type, age, maturity & structure of natural cheese, (3) Characteristics desired in final cheese: optimum emulsification, meltability, homogeneity, stability and flavour.



Thermal Processing

Depends on: (1) Temp. of processing: (a) conversion of casein gel to homo. Casein sol. (b) structural changes desired creaming action, water absorptions, swelling, firming up, etc. and (c) shelf life desired (2) Duration of processing: (a) batch size, (b) quality of raw cheese, (c) other additives, (d) type of final product desired, (e) cooker type, (f) mechanical treatment, (g) emulsifying salt, (h) shelf desired (i) steam pressure, (j) number of nozzles, etc. (3) Agitation (processed cheese- 60 to 90 rpm: processed cheese spread -120 to 180 rpm; depends on (a) thorough mixing, (b) formation of goods sol. and (c) creaming action. Vacuum application is optional (e.g., 30-50 cm, 2-3 min)



Packing

Lacquered foil cardboard/plastic cartons, polystyrene cups glass jars.



Storage (Temp. 5-10 °C)

(Avoid $<5^{\circ}\text{C}$, particularly 0°C as it invites structural changes and changes of condensation on removal from cold storage, hence early spoilage.



Sanitize the Stephan cooker with hot water at 90°C for 20 minutes.



Empty the hot water, add the cheese directly without cooling the cooker and blend for 1 min at low speed (i.e., 750 rpm).

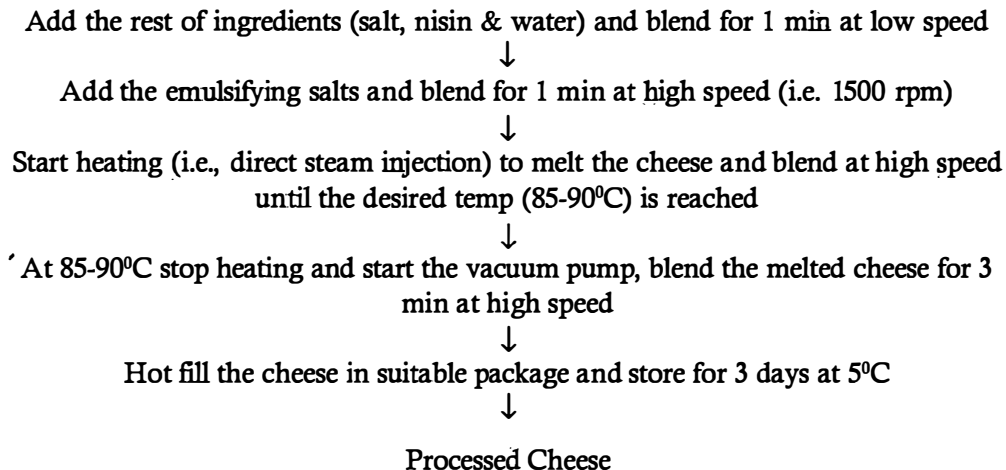


Fig. 12.7: Flow Diagram for Processed Cheese

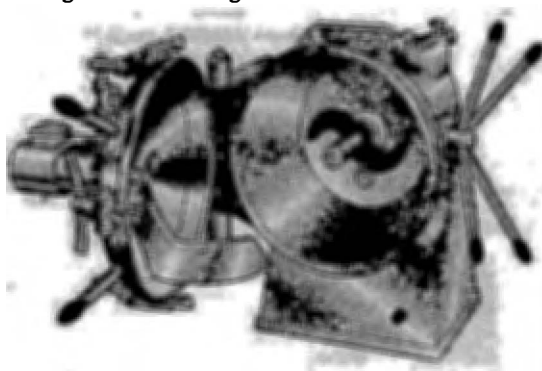


Fig. 12.8 : Cooker, Open & Tilted for Emptying

(III) Mozzarella Cheese:

Mozzarella cheese is the most popular member of Pasta-filata (stretched cured) group of cheese that originated in Southern Italy. It is an un-ripened, renneted, soft, 'spun-cured' cheese variety which is characterized by a structure which resembles that of chicken breast. Its production involves cooking, kneading and stretching of the "ripened" cheese cured (pH 5.2-5.4) at high temperatures (e.g., curd temperature ~ 57-63°C) in hot water (temperature, 77-85 °C) or hot dilute brine (temperature 77-85°C; salt content 5-10 gm/100 ml) into an elastic, cohesive, stretchable mass. The finished Mozzarella cheese, light salted, is white, soft with a very lively surface sheen and has a unique property of stretchability. The cheese when fresh has slightly salty, acid taste and pleasant aroma. It is shaped in various forms such as round cake, oval or egg shaped with weight ranging from 7 to 2000gm. It may also be moulded in large rectangular blocks that could be cut, diced or shredded to size/weight as per consumers demand. The textural and melting characteristics are key determinants of quality of Mozzarella cheese for use on pizza application.

Traditional Mozzarella cheese in Italy is produced from raw buffalo milk. The cheese made from buffalo milk is organoleptically superior to its counterpart from cow's milk, owing to its more piquant and aromatic flavour and better stretch property. Genuine Italian Mozzarella cheese must not contain cow milk. There are many types of Mozzarella cheese (e.g., Mozzarella (regular) having high moisture and high fat; Mozzarella (part skim) having high moisture and low fat; Mozzarella (low moisture) with low moisture and high fat and Mozzarella (low moisture, part skim) "Pizza-cheese" having low moisture, low fat. The cheese is manufactured world-wide from cow's, buffalo's and goat's milk, which has varied composition and functional attributes. The process outlines for manufacture of culture and direct acidified Mozzarella cheese from buffalo milk is depicted in Fig. No – 12.9

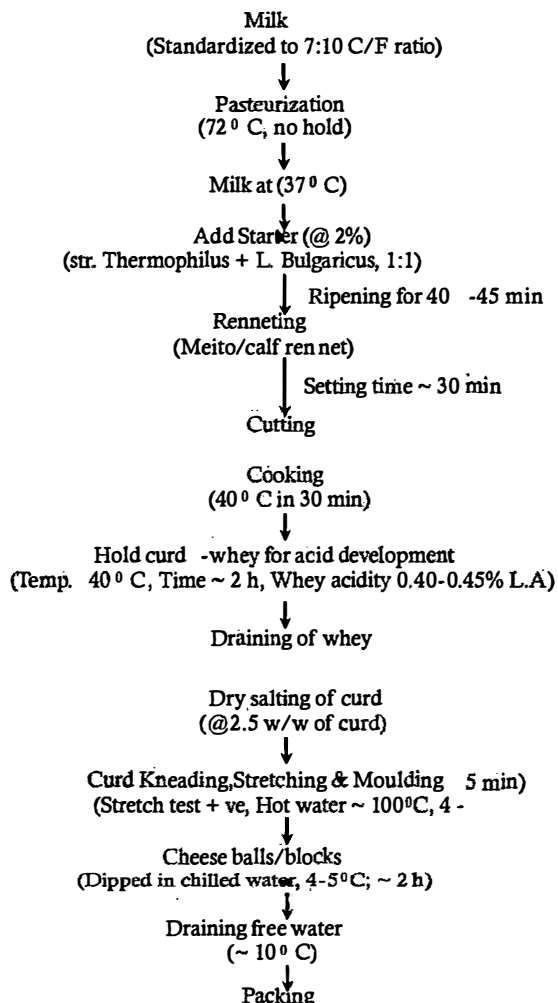


Fig. 12:9: Flow Diagram for Cultured Mozzarella Cheese from Buffalo Milk

Mozzarella cheese Process: Take Standardized, pasteurised buffalo milk in vat and adjust the temperature of the milk to 37°C.

Add active starter culture in the milk at the rate of 2%. Mix the culture thoroughly and measure the acidity of milk. Allow the milk to ripen at 37°C for 40-45 min or till the acidity of milk increases by about 0.01% to 0.02% (as lactic acid).

Rennet the milk with sufficient quantity of Meito rennet to give setting time of about 30-45 minutes at 37°C.

Cut the curd into cubes when the curd has attained desired firmness (firmness of curd is judged subjectively by sense of touch method).

After about 5 minutes of cutting, stir the curd gently with a rack and bring all the cubes in floating condition before starting the cooking/heating.

Cook the curd at 40°C. The temperature of the curd and whey is raised gradually in 30 minutes with continuous agitation. The curd and whey are held at this temperature with intermittent stirring for a period of about 2 hours to develop the desired acidity of whey (i.e., 0.40% to 0.42% lactic acid). Fig. No – 12.10 shows picture of Continuous Cooking – Stretching Machine.



Fig. 12.10 : Continuous Cooking – Stretching Machine

As soon as the acidity of whey reaches 0.4%, separate the curd and the whey by draining the whey through a gate strainer. Since acidity at this stage has a profound effect on the stretchability of the curd during plasticizing it is suggested that a stretchability test may be performed before the curd is salted by dry salting method as followed in cheddar cheese making. This method, though, results in loss of salt in moulding water, is preferred in lieu of brining the cheese at the end as it ensures a uniform distribution of salt throughout the cheese. To compensate the loss that occurs during moulding, a somewhat higher rate of salting is performed. The salt (NaCl) is added at the rate of 2.5% / 3.0% of the weight of the curd.

After about 5 minutes the salted curd is plasticized using boiling water. Sufficient quantity of boiling water is added to cover the curd and a contact time of about 4-5 minutes is allowed. Remove the moulding water completely. Plasticise the hot curd stretching

machine by giving it angular motions till the curd become plastic, single uniform mass. At this stage, the curd can be stretched in the form of long ribbon. Mould this plastic curd into balls or into rectangular slabs by placing the hot plasticized curd in a suitable size hoop.

Promptly remove the cheese balls/slabs from chilled water and transfer to cold store (temperature $< 10^{\circ}\text{C}$) and put them for draining on a stainless steel wire mesh for about 2 hours or until the dripping of water has practically stopped.

The mozzarella cheese balls/slabs are then packed in clean, sanitized polyethylene bags and stored in refrigerator/cold store ($< 8^{\circ}\text{C}$) until used.

Types of Mozzarella Cheese:

i) Bocconicini Cheese

Bocconicini, are small semi-soft white and rindles unripened mild Cheese which originated in Naples and were once made only from buffalo milk. Nowadays they are usually made from a combination of buffalo and cow's milk.

Bocconicini are packaged in Whey or water, have a spongy texture and absorb flavours.

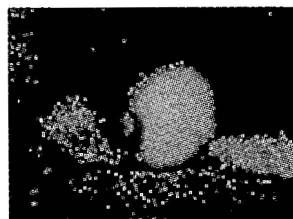
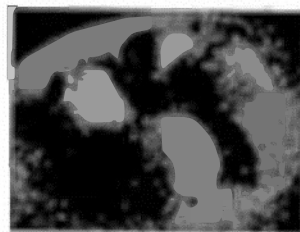
This cheese is described by its Italian name which means small mouthfuls. It is made in the Pasta Filata manner by dipping curds into hot whey, and kneading, pulling and stretching. Each cheese is about the size, shape and colour of a hardboiled egg. Bocconicini can be bought at most Italian supermarkets and is often used in tomato, red onion and basil salads to accompany pasta.

Bocconicini are Italian cheese balls. They taste similar to Mozzarella cheese and are actually a fresh type of mozzarella. Bocconicini are about the size of cherry tomatoes. You can usually find them in delicatessens and some supermarkets in plastic tubs filled with liquid containing whey and/or water.

ii) Smoked Scamorza Cheese :

Scamorza is an Italian cow's milk cheese, similar to mozzarella. It can also be made from other milks, but that is less common. Scamorza is a plastic (or stretched) curd cheese, in which the fresh curd matures in its own whey for several hours to allow acidity to develop by the process of lactose being converted to lactic acid. Artisanal cheesemakers would generally form the cheese into a round shape, and then tie a string around the mass one third of the distance from the top, and hang to dry. The resulting shape is pear-like. This is sometimes referred to as strangling cheese. The cheese is usually white in color unless smoked. When smoked, the color is almond with a lighter interior.

Scamorza can be substituted for mozzarella in most dishes; it is reputed to melt better in baking. Using the smoked variety adds a nice background flavor in replacement of mozzarella.



A spun curd cheese with a very unique shape, it is excellent as a condiment in baked pasta, calzoni and pizzas and also widely consumed uncooked in pasta and rice salads.



Casein & Caseinate

I. Introduction

Casein is the main protein in milk, and is of vital importance to man as a source of protein. Its importance is enhanced by its availability, ease of manufacture and nutritive value.

Recognition of the value of casein as a source of high quality protein for human use and also the development of a number of industrial uses for casein has led to a sudden upsurge in interest in this product over the last ten years.

II. Composition of Casein

Casein is the major protein in milk making up approximately 83% of the total protein in whole milk.

The percentage of casein in normal milk varies between 2.3% and 3.0%. The protein has a highly complex structure and has a large number and range of amino-acid groups. The nutritional value of casein is attributed to the presence of all the essential amino-acids in its makeup.

Casein is actually only a collective term for a number of different protein fractions which occur in milk. These are labelled α casein, β casein, γ casein, etc. The chemical makeup of these substances is very complex and is beyond the scope of the publication.

Commercially produced casein normally contains only approx. 85% of pure casein. The other 15% is made up of water, fat, lactose and minerals.

III. Manufacture of Casein

Manufacture of casein is a relatively simple process. Basically it consists of using some method of coagulating the curd; washing to remove impurities, and, finally, drying and grinding.

The method used for manufacture depends to a large extent on the properties required in the end product. The three most commonly used methods are :-

- (1) Mineral Acid
- (2) Lactic Acid
- (3) Rennet

These refer to the different methods used for precipitation of casein from the skim milk. The hydrochloric acid method is the most common one used in Australia. The lactic acid method, which is used almost universally in New Zealand because the cost of hydrochloric acid was prohibitive, and more recently, because research in that country

has led to the development of continuous method of manufacturing lactic acid casein which is very efficient.

(1) HYDROCHLORIC ACID CASEIN

The process outline for manufacture of casein by this method is shown in Fig. No. 12.11.

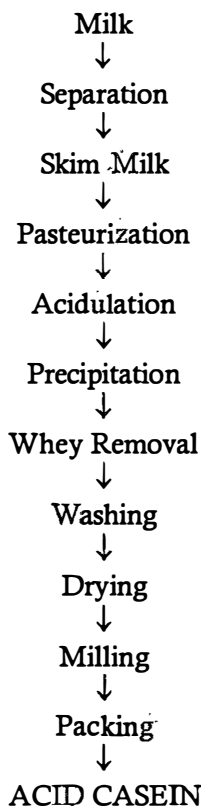


Fig. 12.11: Flow Diagram for Acid Casein

(a) Separation: Separation of milk for casein manufacture has to be carefully controlled. The use of hermetic separators is recommended to prevent air entrainment in the skim milk. Chilled raw milk has to be preheated to $32^{\circ} - 35^{\circ} \text{C}$ before separation. This has a dual effect,

- (a) It approaches the ideal temperature for milk separation.
- (b) A temperature of 32°C is suitable for acidulation.

Higher or lower acidulation temperatures result in higher losses of curd fines in the whey. Separators should be correctly installed and run according to the manufacturer's direction.

(b) Pasteurization : Pasteurization is a prerequisite for edible casein. In the case of skim milk it should be heated in plate pasteurizer to a minimum of 72°C for 15 secs.

Higher temperatures can be used but may lead to curd problems during manufacture. Alternatively the curd may be pasteurized in the second last wash vat by raising the temperature of the water to 80° C.

(c) Acidulation: Skim milk from the balance tank is pumped via a positive displacement pump through a milk/acid mixing valve into the cooking device. The skim milk and acid are mixed by injection of acid in a cone shaped spray against the flow of the milk. This mixing operation is one of the most important in the manufacturing process. It is essential to maintain milk and acid flows at a constant rate (and pressure) hence positive pressure pumps are used. Balance tanks to give a constant head are also required. The acid pump is fitted with a variable speed motor to allow for flow adjustment. Originally the mixing valve used had a fixed setting.

A variation of this system has been reported from France (Gwozdz & Hutin, 1970). Milk and acid are fed under constant pressure into a special pump where mixing is done by a gear system. Cooking is done by direct injection of steam and the curd / whey mixture is held in a pipe of sufficient length and cross section to ensure sufficient holding time to allow firming of curd.

Some plants incorporate a continuous pH recorder at this point as a valuable manufacturing aid. A portion of the whey is directed from the whey off point through the recording pH meter. This unit must be checked frequently against a standard to maintain accuracy.

The commercial hydrochloric acid used is diluted with water to give a strength of 1.3 – 1.5N prior to adding to the skim milk. (N – normality, which is the common term for measuring acid strength. Concentrated hydrochloric acid has a strength of 11N).

Sufficient diluted acid is added to the milk at the mixing valve to give the required pH in the whey (usually about 4.3). The desired pH will vary according to the condition of the milk, (i.e., winter milk may need a different pH to summer milk to get the best results).

The optimum pH of precipitation is obviously the one which will result in the highest yield of casein provided it does not interfere with manufacturing conditions. A good deal of skill and local knowledge is required to run any plant at its most efficient level. The most important single factor is pH control and although a good operator can make casein without a pH meter one would have difficulty in achieving optimum conditions with regards to fines losses.

In general the best results have been obtained with pH values of the milk/acid mix between 4.25 and 4.35.

Most plants are designed to have a fixed ratio of acid flow to skim milk flow. This is usually about 90 L of acid for every 4540 L of skim milk. The flow rate can be altered slightly by altering the acid pump speed. The amount of acid required to precipitate

casein from skim milk is about 5% if 1N acid, i.e., 5/1.4% of 1.4N acid, which is 3.6% of 1.4N acid. To give this strength the concentrated acid must be diluted 11/1.4 times, i.e., approximately 8 times.

(d) Cooking and Precipitation: The cooking device is included in the line only a short distance after the acidulation point. Steam is injected into the acid/milk mixture at 207–276 kilopascals (kPa) (30–40 p.s.i.) to raise the temperature to 43°–46°C. High steam pressures should be controlled by use of a pressure reducing valve. Pressures in excess of 276 kPa (40 p.s.i.) cause damage to the curd, because of the impinging effect of high pressure steam. This often produces a porous curd which may float and prove difficult to wash and pump. Any damage to the curd at cooking will result in excessive fines loss in the whey.

The mixture after leaving the cooking device discharges onto the primary chute which distributes it evenly over the curved back of the riffle chute. This provides sufficient time to allow formation of curd aggregates of 25–50 mm (1–2 inches) in cross section. The correct slope allows for good separation of the curds and whey, but does not allow the aggregates to form into large enough lumps to clog the chute.

The curd / whey mixture falls off the end of the riffle chute onto an inclined screen, the curd falling into the first vat (conditioning vat) containing water at 43°–46° C and whey falls through the screen to waste.

(e) Whey Removal: After being cooked and passed over the riffle chute, the casein curd is concentrated by passage over a stationary inclined screen which removes 70–90% of the whey. This process has an important influence on the overall quality since it has a direct influence on the residual lactose content of the end product and also affects washing efficiency.

Work in Victoria has shown that vibrating screens can be used to separate curds and whey. The types used (Kason and Syntron screens) were tested on a pilot plant scale. The results indicated that both the Kason and Syntron screens were significantly more efficient than the inclined screen in maximising the percentage of total solids in the overflow, (increase of 8–9%). For separation of curd and water, Kason was significantly more efficient than both Syntron and inclined screens (increase of 4.5–5% in total solids in overflow). No difference was found between all types of screens for fines losses.

(f) Washing: The manufacture of high quality casein depends on the efficient removal of lactose from the precipitated curd by thorough washing. The two main techniques of casein washing are the concurrent and countercurrent processes.

The removal of lactose, which is soluble in water, from casein, which is insoluble, is in theory easily achieved, but during the precipitation process, large amounts of lactose are trapped within the curd aggregates and this prevents ready removal during washing.

The removal of lactose from the curd takes place by diffusion into the wash water. To allow sufficient time for this to take place it is necessary to permit an average holding time of 20 – 30 minutes in each wash.

The rate of diffusion of lactose from the curd is controlled by (a) the concentration in the curd, and (b) the concentration in the wash water. In the con-current system in which fresh water is added to each wash vat the rate of diffusion is greater than in a counter – current system in which the water is re-used.

With counter-current washing an increase in water throughput to offset a corresponding increase in milk throughput will lead to a marked increase in residual lactose as a direct result of decreased holding time in each wash vat.

Wash water temperatures have to be varied to suit the curd condition. Normally the first wash or conditioning wash is at 43° – 46° C. The other washes are usually in between these figures. In the case where pasteurization is carried out in the wash vat the second last wash is held at 80° C and the one before that at approximately 60° C.

(g) Pressing : it is normal to “dewater” the curd after the last wash by means of a casein press of which there are several types. The object of pressing is to extract as much water as possible from the curd before it passes to the hot air dryers.

Two factors affect the efficiency of removal of water at pressing:

- (i) The properties of the curd.
- (ii) The adjustment of the press.

One of the properties of casein curd is that it is spongelike in nature. It contracts to expel water when heat is applied (syneresis) and relaxes when the temperature is lowered.

On the application of heat the curd becomes hard and rubbery, while cold water softens it and causes the curd to become fragile and readily broken.

These properties are used in washing as explained in the previous section to facilitate the expulsion of whey from the curd. At high temperature the curd tends to expel moisture without any mechanical pressure. There is however an upper limit to acceptable temperature with pressure; that at which the curd begins to show a tendency to press together in a rubbery mat which does not break up easily. In practice it is usual to have the last wash at 32-41° C.

A wide variation in the percentage of water in curd emerging from the press can be found. (A sample test is to squeeze a handful to give a rapid indication of efficiency of pressing). It is obviously much cheaper to squeeze out water than it is to evaporate it from curd. With good control of wash temperatures and a well adjusted press it should be possible to yield a curd of 55% moisture or even less.

The efficiency of removal of water at pressing will affect the residual lactose content

of the casein. Poorly pressed curd with a lot of loosely held water will yield casein with a higher lactose content than with a properly pressed curd.

(h) Drying: Curd is transferred from the press to the dryer by either a belt conveyor or a screw conveyor. The conveyor delivers the curd to a mincer which breaks it up into small particles to facilitate drying.

Several types of dryers are available. Some of these are:- Ultra, Bates, Proctor Schwartz, Berling, Moa, Pillet, etc. All of these work on the same basic principle. Hot air is blown through the dryer. The prime essential is to dry the curd not bake the curd. Unless the curd has been properly acidulated and washed drying will be difficult. Casein is a difficult product to dry and although it gives up its early moisture freely to approximately 20 – 25% the remaining moisture dries out very slowly. It is extremely sensitive to case – hardening and care must be taken to avoid this defect.

The factors which are important in casein drying are :-

- (i) Type of dryer and construction.
- (ii) Volume of air circulation.
- (iii) Velocity of drying air.
- (iv) Distribution of drying air.
- (v) Drying temperatures.
- (vi) Humidity of drying air.
- (vii) Rate of drying.
- (viii) Cooling of dried product.

Most dryers in casein factories have 2 or 3 stages.

It usually consists of 2 separate units, one which acts as a predryer to bring the moisture down to 30 – 33%, and the second unit which brings the moisture down to 8 – 9%. In small installations only one dryer may be used. The forward movement of the casein is brought about by vibrating stainless steel screens. Hot air after passing through the dryer is drawn off through a hood. Hot air temperatures on a normal 2 deck Bates dryer should not exceed 104° C.

Manufacturing conditions should be carefully controlled to give a curd which will pass through the dryer without lumping or conversely without breaking up into very small particles which can become entrained with the air flow and go out with the exhaust. This occurs to a greater extent in dryers which rely on a high velocity air flow.

Air is generally heated by blowing over steam heated coils. Care should be taken not to heat the air too much. Steam pipes leading to the coils should be fitted with a pressure regulating valve to give a constant pressure at the coils. Condensate from the coils is usually passed out via a moisture trap and should be returned to the boiler for re-use, or, alternatively, can be channeled into a hot water tank.

The exhaust air from dryers is generally blown out through the roof of the building. Some fine casein dust is always found in this air, the quantity depending on (a) the condition of the curd and (b) the type of dryer. Dust collectors are usually fitted to the exhaust vent. These consist normally of a number of frames supporting a filtering medium, e.g., specially woven cloth, nylon, etc. Regular cleaning and servicing of these traps is necessary to prevent a build up in back pressure which cuts down dryer efficiency.

(i) Tempering and Blending: After passing through the dryer the hot, dry casein, which, at this stage is in the form of hard granules, is transferred to large tempering bins. The normal method of transport is by blowing the casein using air as a transporting medium. The casein in the bins is kept agitated by constant conveying. This tempering process is necessary to cool the casein, mix it, and to prevent it from sticking.

Mixing at this point is necessary to overcome the variations which occur with continuous manufacture and to ensure uniformity within the batch. New Zealand workers have shown that good mixing is achieved by conveying from one bin to another. When falling from a central point at the top of the bin a small mound is formed until the bin is full. On emptying from the bottom of the bin a steep sided conical depression is formed and it has been shown that the casein falls equally from the different strata that have been built up within the bin. Satisfactory uniformity even under the worst conditions can be obtained with three complete transfers of a given batch of casein in and out of suitable bins.

Variations in moisture content for casein can be fairly large during a run (e.g., 5% to 15%). Sufficient blending has to be carried out to give a constant result for the batch.

Casein is kept in these bins for a period of usually 24 hours before grinding. Attempts to grind freshly dried casein are not very successful since some of the particles may be slightly “doughy” and soft before tempering.

Sufficient bin space should be allowed to accommodate a full day's manufacture and to allow satisfactory blending to take place.

(j) Grinding, Sifting and Bagging: After blending and tempering has been completed the casein is ground in a roller mill. The grinder is usually installed on floor level and the ground casein is conveyed to the top of a sifting device (usually a gyratory sifter), which is at an elevated level. The sifter is fitted with different size mesh screens to separate the casein into the required sizes. The common sizes are 30 mesh, 60 mesh and 80 mesh screens. Larger pieces of casein are returned via a pipe to the roller mill for regrinding. The casein which passes through the mesh screens is transported to the corresponding bagging – off bin. Some systems incorporate blending bins in the 30 mesh size if a batch system of marketing is used, (i.e., to ensure uniformity within a batch of casein).

The roller mills are equipped with solid steel rollers corrugated or grooved to provide sharp cutting edges. Two rollers are arranged to form a centre V between them and revolve in counter directions. One roller travels at approximately twice the speed of the other (500 to 250 r.p.m.). The depth of the corrugation governs the mesh size of the casein produced.

Hammermills have been used to grind casein but tend to reduce the casein to very fine particles (usually in size of 100 mesh or finer).

All casein grinding and sifting equipment should be fitted with efficient dust collectors to cut down fines losses and operator discomfort.

Casein is usually packed into a multiwall paper bag with a polythene liner and removed to the dry storage section.

(k) Dry Storage: The store should be designed to permit the maximum possible storage for the minimum capital investment. Casein storage areas are usually portal frame construction, approximately 6 m (20 feet) high and up to 23 m (75 feet) wide.

A prime objective in the store is to control temperature and humidity without using a system of heating or cooling. This can be done by providing a store with good insulation and by reducing the rate of air change to a minimum.

(2) SULPHURIC ACID CASEIN

Sulphuric acid is by far the cheapest mineral acid available for casein precipitation. In addition to this, it is stronger, and one ton of sulphuric acid will make approximately 9.46 ton of casein in contrast to one ton of hydrochloric acid which makes 5 ton of casein.

Before 1952, sulphuric acid casein was produced in the United States of America by pressed curd and cooked curd techniques. Both of these techniques gave a casein with a high ash content and consequently high viscosity. This product was not very suitable for a number of industrial processes and a marked buyer resistance to sulphuric acid casein was built up.

Research in recent years has shown that a good quality sulphuric acid casein can be manufactured with properties equaling those of the best hydrochloric acid and lactic acid caseins.

The method used for manufacture of sulphuric acid casein is almost identical to that described for hydrochloric acid casein, except that the acid has to be diluted to a much greater extent. Concentrated sulphuric acid is approximately 36 Normal and conc. Hydrochloric is only about 11 Normal, hence sulphuric acid has to be diluted 36/1.4 (=26) times to give an acidity of 1.4N.

(3) LACTIC ACID CASEIN

The lactic acid casein manufacturing method has evolved from traditional procedures of making casein in cheese vats. Skim milk is usually inoculated with starter in large storage vats of from 18000–113000 L capacity. The coagulating process takes about 16 hours to reach a pH of approximately 4.5. The curd is then pumped via a direct steam injector where it is heated to around 52°C and passed through a holding pipe and / or vat to allow the curd to form.

The curds/whey mixture passes to a dewheying screen and then through a series of washes. There are a number of variants to the washing process but the two main processes are the D-vat system and the McKenzie & Ridley system.

In the former system the curd is separated from the whey on an inclined screen and then falls into a D-vat where it is agitated with wash water at, usually, 57°C. The curds and water are pumped continuously from the end of the vat onto an inclined screen and into a similar vat at 68°C (approx.). This process is repeated in a third wash at approximately 80°C and in a fourth wash at about 32°C before being discharged on to a final stationary type screen to a roller type press.

The McKenzie & Ridley equipment consists of a moving fine mesh belt on which the curd is held while the whey passes through. It may also be sprayed with water while traveling up the belt. It is discharged into the first stage of the washing machine in which the curd and wash water are agitated and the curd is finally removed via a chain of perforated buckets which transfer the curd to the next vat. Wash water is removed from the machines through rotating fine mesh screens which reduce fines losses. After several washes the curd is pressed on a belt which passes through a series of rollers. It is then discharged to the dryers. Counter – current wash water flow may be used and temperatures are similar to those used in the D-vat process.

Drying, grinding, sifting and bagging of lactic acid casein is done in a similar manner to that already described in the mineral acid casein process.

(4) RENNET CASEIN

Rennet casein is manufactured by warming skim milk to about 31 – 32°C, and adding rennet to cause coagulation in about 30 minutes. The coagulum is heated in a jacketed vat with careful control of rate of heating and agitation to reach about 57°C after 1 hour.

The particle size is controlled during the coagulation and cooling stages.

Following cooking, the curds and whey are separated and the curd is passed to washing and drying system similar to those used for lactic acid casein.

Some variations in the methods of manufacture of rennet casein including processes

for continuous coagulation and changed agitation procedures during clotting have been tried, but have not proved to be fully successful.

Rennet casein has a different composition to acid precipitated casein and has different properties.

Composition and Quality Control

Each step in the manufacture of casein must be carefully controlled to obtain high quality, correct composition, and high yields. Two of the most important factors involved are: efficient separation of fat from the milk (0.5 or less) because fat lowers the quality of the casein; and thorough washing of the curd to reduce whey components, especially keeping lactose and minerals to a minimum. Lactose in the casein causes a brown discolouration to develop and lowers solubility.

Proper pH at the time coagulation is considered to have complete influence on the particle size. The particles are too small if there is too much acid and too coarse if not enough acid is allowed to develop. Correct acidity when curd is cut also aids in obtaining a low mineral content of the casein as well as influencing odor and subsequent viscosity of the relquefied product. A high heat treatment (including drying temperature) will reduce dispersibility.

Yields are affected by completeness of precipitation of the casein, loss of curd particles during whey and wash water drainage, completeness of washing, solids loss during pressing, and the final moisture content of the casing. Protein content of skim milk, which normally ranges from 2.8 to 3.0 kg. per hundred kg, obviously affects the yields.

The composition of an acid coagulated casein may average within the following ranges:

Constituents	Percent
Protein (N X 6.38)	88.0 to 90.0
Fat	0.5 to 1.5
Ash	3.5 to 4.5
Moisture	4.0 to 12.0

Uses

Acid casein is used in various industries. It serves as an adhesive to bind clay pigments for the coating of paper. In this case freedom from insoluble particles and fat and the adhesive strength become important quality factors. Limited amounts of casein have also been used for glue, paint, and plastic manufacture. Food and medical products are other possible outlets for this product.

SODIUM CASEINATE

Sodium caseinate is made from edible-grade casein, solubilized with pure sodium hydroxide. The resulting solution is spray-dried to form a product that contains not over five percent moisture.

Skimmilk is preheated to 46° C. Hydrochloric acid which is sufficient to bring the pH slightly below the isoetetic point is diluted with four parts of water and added to the skimmilk with thorough mixing. Precipitated casein and whey are separated by centrifuge. The curd is then milled to break up casein lumps. Water at 38° C is used for washing the curd. One, two or more washings are required, depending upon desired purity for the final product. The water is removed by centrifugation or drainage. For a higher purity the curd is pressed to remove additional whey. The roller press is more suitable for large quantities.

A 0.5% solution of sodium hydroxide at 66° C is used to disperse the curd and return the pH to the approximate neutral point of 7.0. Solids content of the slurry is usually controlled to 15 to 20% for spray drying.

The material is then spray dried using an outlet air drying temperature which reduces moisture to 3.5 to 4.5%. The final product then is sifted and packed in dry milk containers. A normal yield is approximately 3 lb. per hundred wt. of skimmilk.

The pH range in a good quality product will be 6.5 to 7.2. Sodium caseinate should be white or a very light cream colour and free of off-flavors and odors. Bulk density is 0.2 to 0.3 gm. per ml.

Utilisation

Sodium caseinate functions as a binder, emulsifier and whipping agent in food products. Because of its nutritional value it is utilized as a source of protein in dry cereals or other starchy products and in special foods for infant, dietetic, and diabetic products. Sodium caseinate enhances whipping properties of ice milk or ice cream, toppings, and whipping cream products. It also improves body and texture and reduces shrinkage of these products. Usage generally is 2.0 to 4.0% of total solids of the product. It also functions as an important component in non-dairy creaming and coffee colouring products, both liquid and dry. Sodium caseinate serves a useful purpose in sausage, other types of processed meat products and meat substitutes. The recommended amount usually is 1 to 2% of the total meat product.

(5) CALCIUM CO-PRECIPITATE

The manufacture of co-precipitate depends upon the linking together of the milk proteins so that when casein is precipitated a large part of the other milk protein comes down as well giving higher yields and a nutritionally more valuable product.

A process has been developed by Commonwealth Scientific Industrial Research Organisation (CSIRO), Australia, for the continuous manufacture of calcium co-precipitate using the basic plant as for hydrochloric acid casein with some modification. This process will recover 95 – 99% of the milk protein compared with only about 80% recovery in casein manufacture.

Steps in the manufacture of calcium co-precipitate are outlined in the flow diagram shown in Fig. No - 12.12

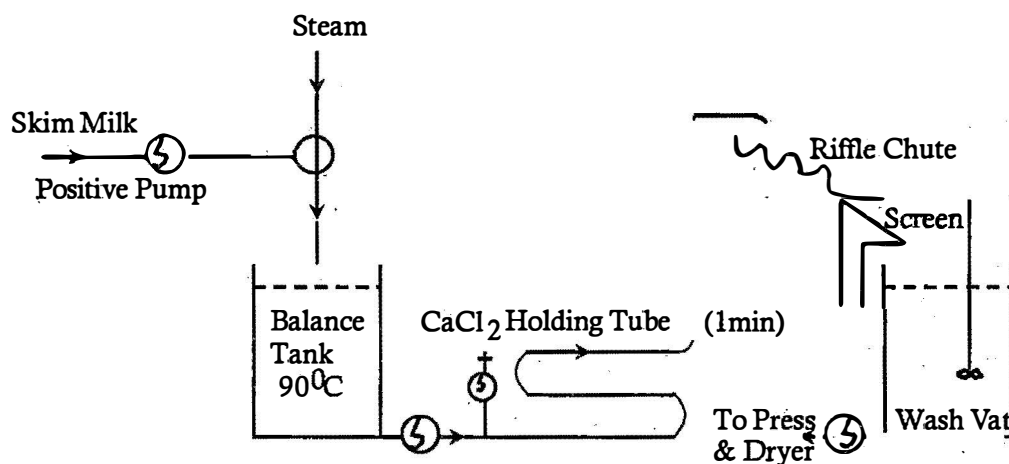


Fig. 12.12 : Flow Sheet for Manufacture of Co-Precipitate.

The addition of calcium chloride at levels of upto 0.3% is used in conjunction with temperatures of approximately 90° C to form the co-precipitate.

The curd is washed, and pressing and drying are carried out as with normal casein.

For spray drying purposes, the wet curd can be redispersed in water containing sodium tripolyphosphate and passed through a spray dryer.

Since the initial commercial method was developed, a number of modification to the process have been evolved to make a product which is "tailor-made" for a specific purpose e.g., baked goods. Methods have been found to manufacture co-precipitate of high, medium and low calcium contents. Each of these products has different properties.

Further research work is now being carried out to fully investigate the properties of co-precipitate and the effect that changes in manufacturing techniques will have on these properties.

At present only a small quantity of co-precipitate is being manufactured in Australia but this is sure to increase over the next few years. Co-precipitate has been found to be superior to milk powder for a number of purposes particularly as it contains very little

lactose, and new uses are being investigated.

Whey Production and Processing

Whey the largest byproduct of the dairy industry obtained during the manufacture of Cheese, Paneer, Chhanna and Casein, contains about 10% of total milk proteins and most of the water-soluble vitamins, lactose and minerals. In India, there has been a considerable increase, in the recent past, on the production of direct acidified indigenous milk products resulting in increased availability of whey. About 3 million tons of whey is produced annually in India containing about 2 lakh tons of valuable milk nutrients.

Importance of Whey Utilization

Whey constitutes about 80-90% of volume of milk used for conversion into Chhanna, Paneer and Casein. It retains about 45-55% of the milk nutrients comprising serum protein, lactose, minerals and vitamins. There is an increased awareness all over the world on the potential utilization of whey primarily due to pollution prevention regulations, economic conditions and future needs to ease the world food shortage and its excellent nutritional properties.

Applications of whey

In Whey Beverages: By using the whey as raw material we can produce various Whey products in different forms like liquid, concentrated, dried and fractionated and fermented products. The liquid whey can also be used as animal feed but it has limitation since the dairy farms are scattered over a wide region and the whey is available in particular location and the logistics of moving it may be prohibitive. An alternative means of whey utilization could be the development of whey beverages with or without addition of fruit pulp.

The major advantages offered by whey as a substrate for beverage production are that it has greater nutritive value and is more thirst quenching, than most soft drinks and is less acidic than fruit juices.

In Cheeses: Whey is suitable for the propagation of lactic cultures used in the manufacture of various types of cheeses. In cheeses, the whey proteins can be increased by the use of UF-based cheese manufacturing technology, which involves initial concentration of cheese milk, by UF. During the coagulation process whey proteins get trapped in the coagulum as a result less moisture is expelled from the curd with increased retention of water soluble components of milk in cheese. By increasing the level of whey protein incorporation, the cheese yield and nutritive value of product are increased. This process has been widely applied for producing different cheese varieties like Cheddar, Gouda, Mozzarella and Cottage cheese.

In Soups: In the recent years, whey based ready-to-serve soups are gaining importance as convenience foods, which can serve as highly nutritious, energetic and refreshing foods. However, there is a paucity of information available on the standardization and

development of whey-based vegetable soups.

In Baked Foods: Use of whey in baked foods is claimed to improve the characteristics including flavour, colour, porosity, consistency and volume. In addition, baking losses and fermentation time were reduced and increase in the bread yield was observed. Dough fortified with 1% whey protein concentrate (WPC) resulted in bread which showed a loaf volume depression of <5%, while bread fortified with defatted WPC resulted in depression of 15%, which indicated that lipid fraction in whey is indispensable for baking properties of WPC in bread. Liquid whey can also be used in bakery and fried food products where the golden crust is important. It can also be used in caramels, confections and candies to reduce sweetness, prolong shelf life and improve the nutritional quality. Upto 25% of milk solids-not fat content of ice cream and other dairy-based frozen desserts can be replaced with dried whey without adversely altering their quality attributes. Upto 8-10% lactose hydrolyzed whey was used successfully for formulating ice-cream mix and to replace sweetened condensed milk in bakery and flavoured beverages.

In Meat Products : In meat industry, whey proteins contribute desirable functional properties and have been extensively used as fillers, binders and extenders in comminuted meat products. These proteins improve the emulsifying capacity, emulsion stability, water binding and slicing characteristics with reduced cook shrink and formulation costs. They also significantly increase the gel strength of meat proteins by the synergistic effect between whey and meat proteins through covalent cross linkages. In sausages, the whey proteins help to increase the product yield and control flavour and protein losses. However, calcium present in whey has to be removed which interferes with the solubilization and functionality of meat myofibrillar proteins. Partial demineralization can be a suitable answer to overcome this problem.

WHEY PROCESSING

Whey comprises 80-90% of the total volume of milk entering the process and contains about 50% of the nutrients in the original milk: soluble protein, lactose, vitamins and minerals. Whey as a by-product from the manufacture of hard, semi-hard or soft cheese and rennet casein is known as sweet whey and has a pH of 5.9 – 6.6. Manufacture of mineral-acid precipitated casein yields acid whey with pH of 4.3 – 4.6. Table No – 12.4 shows approximate composition of whey from cheese and casein manufacture.

Different Whey Processes

Whey must be processed as soon as possible after collection, as its temperature and composition promote the growth of bacteria. Otherwise the whey should be quickly cooled down to about 5°C to temporarily stop bacterial growth.

Casein Fines Recovery and Fat Separation

Casein fines are always present in whey. They have an adverse effect on fat separation and should therefore be removed first. Various types of separation devices can be utilized,

Table 12.4 : Approximate Composition of Whey (in %)

Constituent	Cheese Whey %	Casein Whey %
Total solids	6.4	6.5
Water	93.6	93.5
Fat	0.05	0.04
True Protein	0.55	0.55
NPN (Non-protein Nitrogen)	0.18	0.18
Lactose	4.8	4.9
Ash (Minerals)	0.5	0.8
Calcium	0.043	0.12
Phosphorus	0.040	0.065
Sodium	0.050	0.050
Potassium	0.16	0.16
Chloride	0.11	0.11
Lactic acid	0.05	0.4

such as cyclones, centrifugal separators or rotating filters. Fat is recovered by centrifugal separation.

The fines are often pressed in the same way as cheese. After which they can be used in processed cheese and, after a period of ripening, also in cooking.

The whey cream, often with a fat content of 25 – 30%, can be re-used in cheese making to standardize the cheese milk; this enables a corresponding quality of fresh cream to be utilised for special cream products.

Cooling and Pasteurisation

Whey which is to be stored before processing must either be chilled or pasteurized as soon as the fat has been removed. For short time storage, 10 – 15 hours, cooling is usually sufficient to reduce bacterial activity. Longer periods of storage require pasteurization of the whey.

Concentration of Whey

Whey concentration traditionally takes place under vacuum in a falling-film evaporator with two or more stages. Evaporators with upto seven stages have been used since the mid-seventies to compensate for increasing energy costs. Mechanical and thermal vapour compression have been introduced in most evaporators to reduce evaporation costs still further.

After evaporation to 45 – 65% total solids, the concentrate is cooled rapidly to about 30°C in a plate heat exchanger and transferred to a triple jacketed tank for further cooling to 15 – 20°C accompanied by constant stirring. This may continue for 6 – 8 hours to obtain the smallest possible crystals, which will give a non-hygroscopic product when spray dried.

Concentrated whey is a supersaturated lactose solution and, under certain conditions of temperature and concentration, the lactose can sometimes crystallise before the whey leaves the evaporator. At concentrations above a DM content of 65% the product can become so viscous that it no longer flows.

Drying

Spray drying of whey is at present the most widely used method of drying. Before being dried, the whey concentrate is usually treated as mentioned above to form small lactose crystals, as this results in a non-hygroscopic product which does not go lumpy when it absorbs moisture.

Fractionation of Whey

Whey Protein Concentrate (WPC)

Whey protein concentrates (WPC) are powders made by drying the retentates from ultrafiltration of whey. They are described in terms of their protein content, % protein in dry matter, ranging from 35% to 85%. To make a 35% protein product the liquid whey is concentrated about 6-fold to an approximate total dry solids content of 9%.

In concentration most of the true protein, typically > 99%, is retained together with almost 100% of the fat. The concentrations of lactose, non protein nitrogen and ash are generally the same in the retentate serum and permeate as in the original whey, but a slight retention of these components is reported. The overall retention figures, however, depend very much on the type of membrane, the flux, and the character of the feed. Table No 12.5 shows the compositions of some typical WPC powders.

Table 12.5 : Composition of Some Whey Protein Concentrate Powders (in %)

Product	1	2	3	4
Protein in Dry Matter	35	50	65	80
Moisture	4.6	4.3	4.2	4.0
Crude Protein (Nx6.38)	36.2	52.1	63.0	81.0
True Protein	29.7	40.9	59.4	75.0
Lactose	46.5	30.9	21.1	3.5
Fat	2.1	3.7	5.6	7.2
Ash	7.8	6.4	3.9	3.1
Lactic acid	2.8	2.6	2.2	1.2

First the whey is preheated and separated to recover as much fat as possible in the form of 25-30% cream. This cream can be re-used for fat standardization of cheese milk. The separation stage also removes fines. After this the whey is pasteurised and cooled to about 55-60°C before being transferred to an intermediate holding tank. After this the whey is pumped to the first UF plant where it is concentrated about threefold. The retentate is pumped to the MF plant while the permeate goes to a collecting tank after regenerative cooling.

The retentate from MF treatment, which contains most of the fat and bacteria, is cooled separately, and the defatted permeate is forwarded to further ultrafiltration with diafiltration. The resulting WPC with about 20-25% DM is then spray-dried to reduce the moisture content to a maximum of 4% before bagging. The Flow Diagram of WPC is shown in Fig. No - 12.13

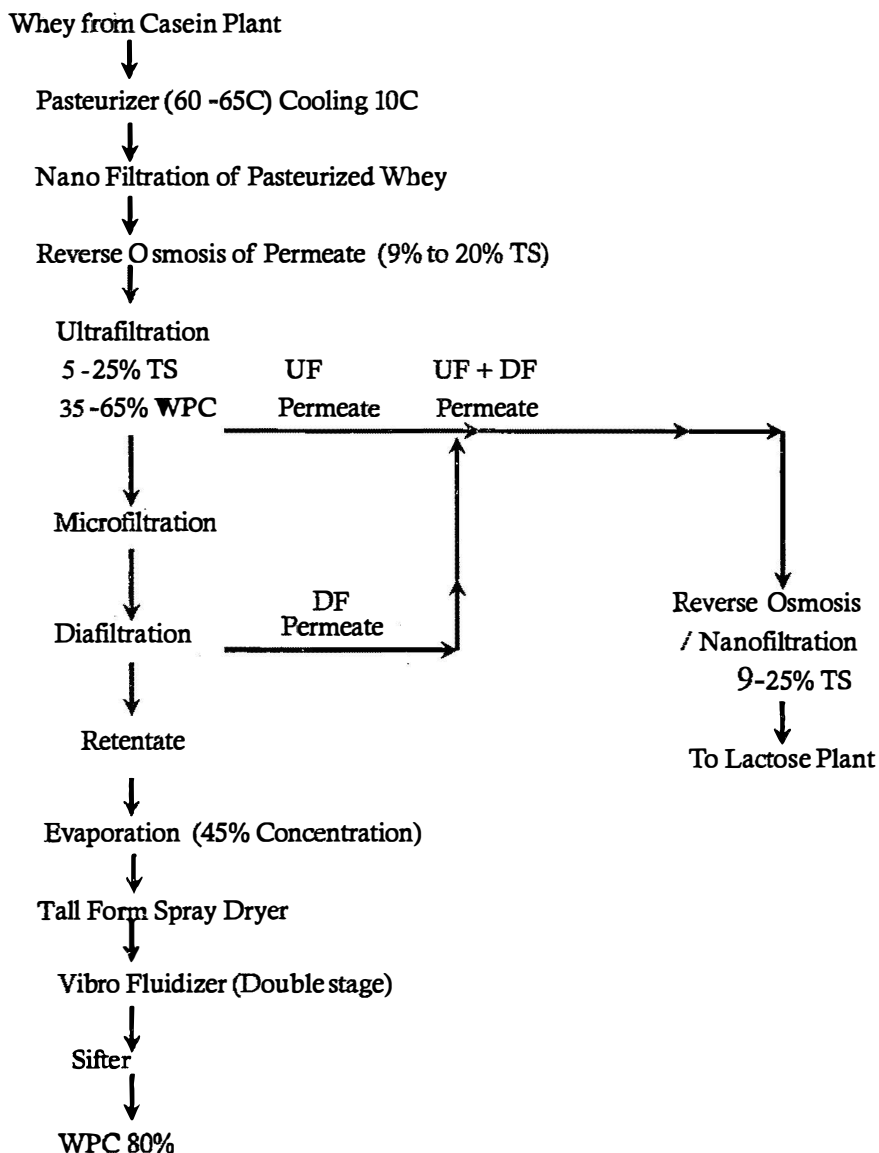


Fig 12.13: Flow Diagram of WPC Powder

Chromatographic Isolation of Lactoperoxidase and Lactoferrin

Generally speaking, use of natural bioactive agents is of very great interest in products like infant formulas, health foods, skin creams and toothpaste. Examples of such components are the bioactive proteins lactoperoxidase (LP) and lactoferrin (LF) existing at low contents typically 20 mg of LP and 35 mg of LF per litre of whey. The Swedish Dairy Association (SDR) has developed a patented process based on chromatography for isolation of these proteins from cheese whey on an industrial scale.

The basic principle underlying the process is the fact that both LP and LF have isoelectric points in the alkaline pH area, 9.0 – 9.5, which means that these proteins are positively charged at the normal pH of sweet whey, 6.2 – 6.6, while the rest of the whey proteins e.g., β -lactoglobulin, α -lactalbumin and bovine serum albumin are negatively charged in the same pH range. A fundamentally suitable process for isolation of LP and LF is therefore to pass a specially designed cation exchange resin for selective adsorption. The LP and LF molecules thus bind to the negatively charged functional group of the cation exchanger by charge interaction, leading to fixation of these molecules on the ion exchange resin, while the other whey proteins pass through because of their negative charge.

To make the process industrially viable, some basic criteria have to be satisfied. One of them is the need for rate during the loading phase, because very large volumes of whey have to pass the ion exchange resin to achieve saturation. Cross-flow microfiltration (MF) with a pore size of 1.4 μm operated under a uniform transmembrane pressure (UTP) has proved to be a successful technique for getting particle – free whey. Stable flux of 1200 – 1500 L/m²h is easily sustained for 15 – 16 hours. This type of pretreatment of the whey avoids build-up of increasing back pressure over the ion exchange column.

The ion exchange resin has a capacity to adsorb altogether 40 – 45 gm of LP and LF per liter resin before breakthrough occurs. With a resin bed volume of 100L, almost 100000 L of whey can be treated per cycle.

With properly chosen conditions for elution of adsorbed bioactive proteins on the column it is possible to obtain very pure fractions of LP and LF. Salt solutions of different strengths are used for this step. The proteins in the eluates occur in fairly concentrated form, of the order of 1% by weight. The ion exchange step concentrates LP and LF by a factor of almost 500 compared to the original whey. Further processing of the eluates by UF after sterile filtration in a cross-flow microfilter with 0.1 – 0.2 mm pores, the protein concentrates are spray dried. The overall process is illustrated in Fig. No – 12.14

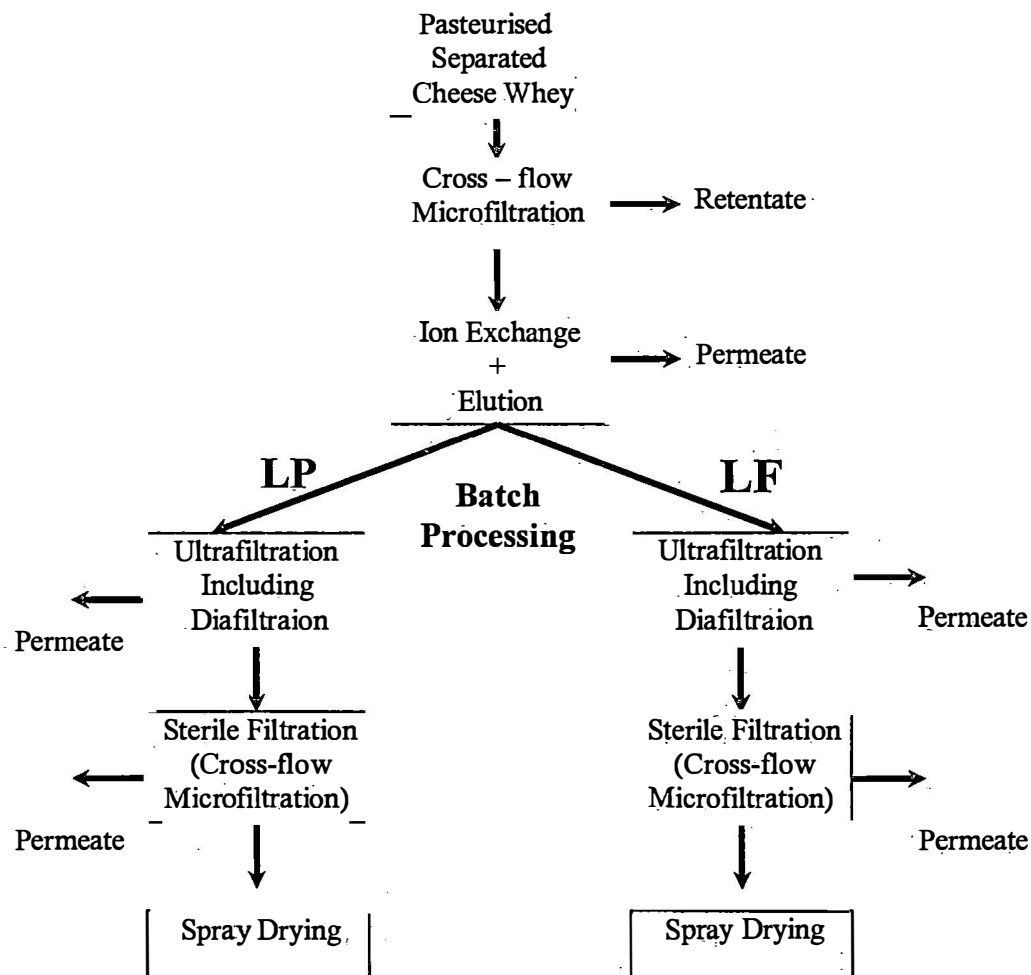


Fig. 12.14 : Block Diagram for isolation of lactoperoxidase (LP) and lactoferrin (LF) from whey

Demineralisation of Whey

As whey has a fairly high salt content, about 8 – 12% calculated on dry weight, its usefulness as an ingredient in human foods is limited. By having the whey demineralised, various fields of application can however be found for whey demineralised, which is partially (25 – 30%) or highly (90 – 95%) demineralised.

Partially demineralised whey concentrate for instance can be used in the manufacture of ice-cream and bakery products or even in quark whereas highly demineralised whey concentrate or powder can be utilized in formulas for infants and in a very wide group of other products.

Principles of Demineralization

Demineralisation involves removal of inorganic salts together with some reduction in the content of organic ions such as lactates and citrates. The partial demineralization is mainly based on utilisation of cross-flow membranes specially designed to “leak” particle species that have radii in the nanometer (10^{-9} m) range. This type of filtration is called nanofiltration (NF).

The high degree desalination is based on either of two techniques:

- Electrodialysis
- Ion exchange

High Degree Demineralization

Electrodialysis

Electrodialysis is defined as the transport of ions through non-selective semi-permeable membranes under the driving force of a direct current (DC) and an applied potential. The membranes used have both anion and cation exchange functions, making the electrodialysis process capable of reducing the mineral content of a process liquid, for example seawater or whey.

Operating Principle

Alternate cells in the electrodialysis stack act as concentration and dilution cells respectively. Whey is circulated through the dilution cells, and a 5% brine carrier solution through the concentration cells.

When direct current (DC) is applied across the cells, cations attempt to migrate to the cathode and anions to the anode. However, completely free migration is not possible because the membranes act as barriers to ions of like charge. Anions can pass through an anion membrane, but are stopped by a cation membrane. Conversely, cations can pass through a cation membrane but not an anion membrane. The net result is depletion of ions in the whey (dilution) cells. The whey is thus demineralised, to an extent determined by the ash content of the whey, residence time in the stack, current density and flow viscosity.

Limiting Factors in Electrodialysis

A major limiting factor for using electrodialysis in dairy processing is the cost of replacing membranes, spacers and electrodes, which constitutes 35–40% of the total running costs in the plant. Replacement is necessary due to fouling of the membranes, which in turn is caused by:

- Precipitation of calcium phosphate on the cation exchange membrane surfaces
- Deposition of protein on the anion exchange membrane surfaces.

The first problem can be handled by proper flow design over the membrane surface and regular acid cleaning.

Protein deposits are the main factor in shortening the lifetime of the anion membranes. The background to this problem is as follows: at the normal pH of whey, the whey proteins can be regarded as large negative ions (anions) and move as such under the influence of the electrical field in the stack. These molecules, being too large to pass through the anion exchange membranes, are deposited as a thin protein layer on the faces of the anion exchange membranes in the whey compartments. Techniques such as polarity reversal can be used to dislodge these deposited materials from the membrane.

Although frequent high-pH cleaning removes most of the deposits, disassembly of the stack for manual cleaning is recommended at intervals of 2 – 4 weeks.

The processing cost of electrodialysis depends very much on the demineralisation rate. Increasing the capacity in steps from 50% to 75% to 90% doubles the processing cost per step. This means that it is four times as expensive per kilo of product solids to demineralise to 90% than 50%; the reason is that plant capacity is reduced at 90% demineralization.

Electrodialysis is best for demineralisation level below 70%, where it is very competitive compared to ion exchange.

Ion exchange process for demineralisation

Demineralisation by ion exchange has long been an established process for water treatment but has also been adopted during the past two decades for “de-ashing” of whey. Whey is not a uniform product when it comes to its composition. Whey from an acid casein/ cheese curd has a pH of 4.3 – 4.6, while the pH of sweet whey is 6.3 – 6.6. The main difference between these two types of whey, apart from the acidifying medium, is the high level of calcium phosphate in the acid whey. It is good practice to use the cations as the base for calculating the salt load in whey because the anions, e.g., citrates and phosphates, are involved in proteolytic reactions. This complicates the calculation of specific ion contents.

Process limitations

Whey is a liquid with a high salt load, which means short runs between regenerations. It also means a high consumption of regeneration chemicals and a high salt load in the waste from both ash removal and the required surplus of regeneration chemicals. Rinse – water consumption is also high, especially for washing out excess sodium hydroxide from the weak anion resin.

Losses of whey proteins occur on the columns due to denaturation / absorption. This is caused by great pH variation in the whey during the ion exchange process. Consumption of regeneration chemicals accounts for 60 – 70% of the operating costs of the process.

The process is primarily designed for 90% demineralisation, but any demineralization rate can be chosen if a by-pass system is used. In Fig. No. 12.15 shows flow diagram for Demineralized Whey Powder.

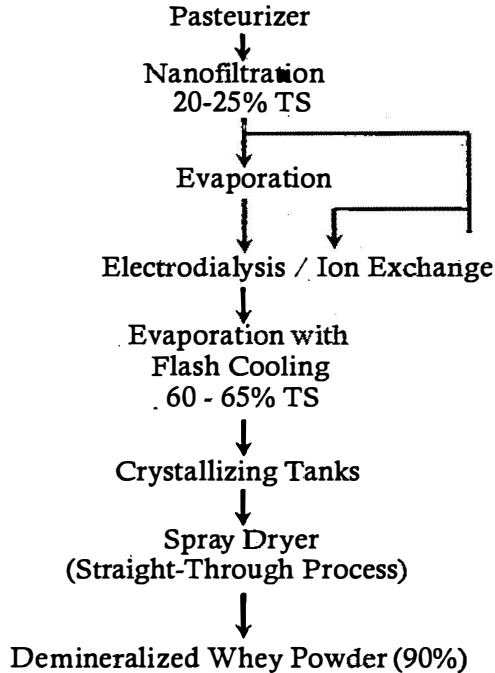


Fig. 12.15: Flow Diagram for Demineralized Whey Powder

WHEY DRINK STRAWBERRY

One possible application of whey is in Whey Drink. One of the most known, most popular and also most traditional flavours is the Strawberry flavour. Available in many different versions it is perfect for the application in a very wide range of foodstuff. The strawberry when drink formula is as under:

Whey	:	900 gm
Fructose	:	50.00 gm
Dextrose	:	20.25 gm
Crystal sugar	:	25 gm
Citric acid solution 50%	:	3 gm
Stabilizer E 440 (DANISCO)	:	1 gm

Colour

Apple Juice Concentrate 70° Bx	1.55 gm
Strawberry Flavour 0040076	0.6 gm

Manufacture

Adjust the whey with citric acid solution to pH 4.1 – 4.2 Mix all the dry components to a premix. Heat the whey up to 40° C and add the premix, the Apple Juice Concentrate, the flavours and the colour slowly. Pasteurize and cool down immediately.

Lactose

The entire quantity of lactose rich solution would be evaporated to 60% solids in multiple effect evaporating plant. Concentrated solution of lactose would then go for crystallization in specially designed crystallizer where it would be crystallized. After crystallization there will be series of washing. Finally concentrated lactose slurry will pass through a centrifuge and finally dried in a fluid bed dryer.

Figure No - 12.16 shows a production line for manufacture of lactose.

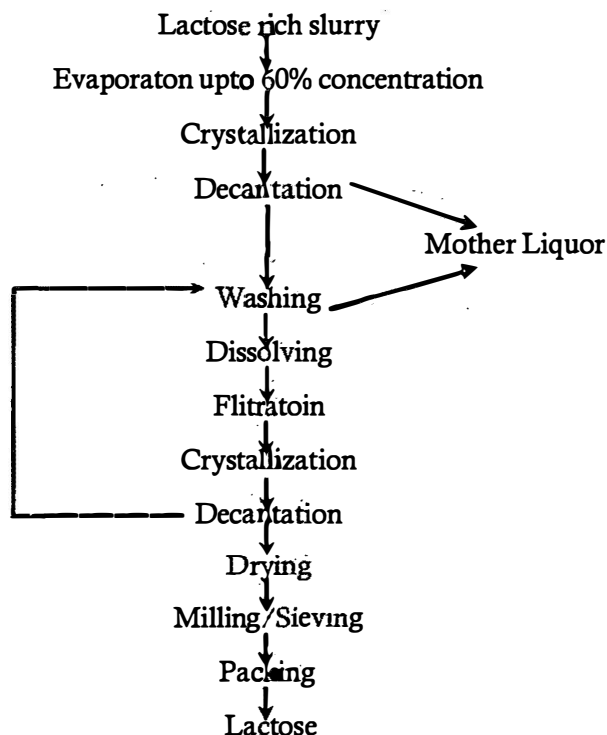


Fig. 12.16: Process Line for Lactose Manufacture

Milk Calcium

Calcium stands out as an essential mineral for its multiple role in making human bodies healthy. The importance of dietary calcium in the early years of life to achieve optimal peak bone mass is well established.

Milk and Milk products are important sources of this essential mineral. They contribute significantly to fulfill the recommended daily requirements for calcium and other minerals. Several studies have provided evidence that calcium intake in the growing stage (2-18 yrs) is significantly and positively associated with bone mineral density.

A relatively new concept in India, milk calcium refers to a mineral that is scientifically extracted from milk. A dairy ingredient in itself is natural, safe and in contrast to many other calcium sources, virtually free from heavy metals. Thus, milk calcium is a completely safe source of dietetic calcium with a varied spectrum of distinct advantages.

The basic role of Calcium can be categorised as:

- For healthy teeth bone formation (98-99%).
- The level of ionized calcium to be maintained in blood.
- To maintain certain basic regulatory functions like:
 - Contraction and relaxation of muscles (including normal heart beat).
 - Coagulation of blood.
 - Transmission of blood.
- Activation of enzyme reaction.
- Stimulation of hormone secretions.
- Integrity of intercellular cement substances.

Milk Calcium Separation Process in Brief:- The careful process of its extraction from milk involves the following stages. Manufacture of Milk Calcium is given in Figure No. 12.17

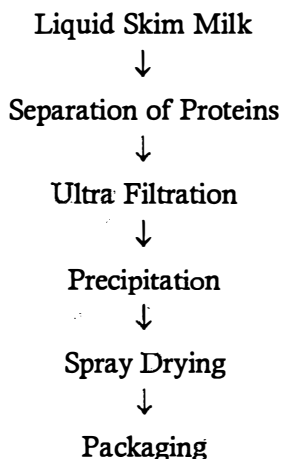


Fig. 12.17 : Manufacture of Milk Calcium

Fig. No -12.18 shows flow chart for manufacture of different Whey Products from Whey.

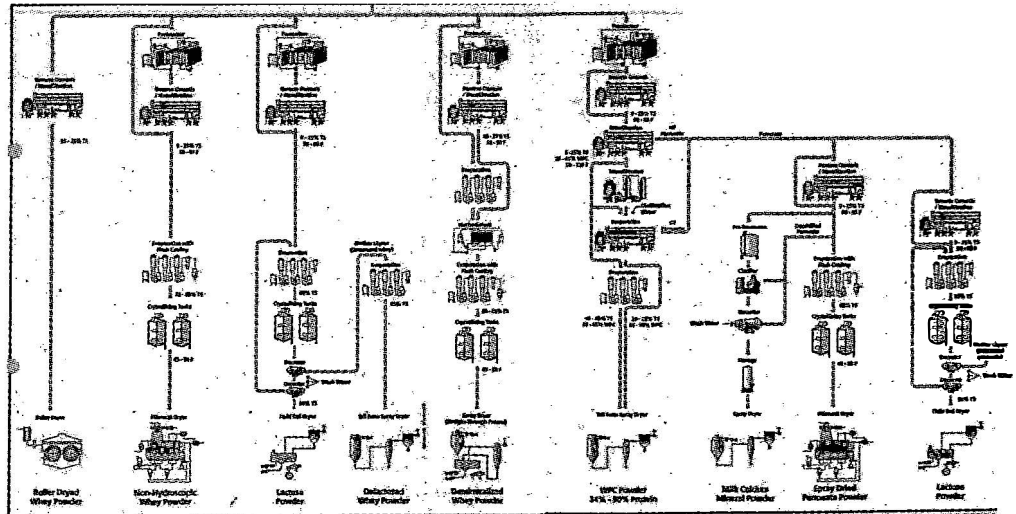


Fig. 12.18: Flow Chart for Manufacture of Different Whey Products from Whey.

Chapter 13

Evaporated and Sweetened Condensed Milk

Condensed milks are the products obtained by evaporating part of the water of whole milk, or fully or partly skimmed milk, with or without addition of sugar.

Condensed whole milk and condensed skim milk are common industry terms that refer to products obtained from respective milk with increased solids content, achieved by the removal of water under a vacuum. These products may be identified with their solids content, for example, 40% condensed skim milk. They are packaged in large containers or handled by bulk means for industrial uses in the non-sterile condition.

Sweetened condensed whole milk and sweetened condensed skim milk have sugar added as a preservative. These products are not sterilized. Sweetened condensed milk may be packaged in retail cans, large containers, or transported in bulk form.

EVAPORATED MILK

Heat Stability

Ideally, milk or evaporated milk should have no developed acidity, but the maximum acceptable range extends from 0.18 to 0.22% LA, depending on initial titrable acidity. Heat stability of the milk is important if the product is sterilized during manufacture. The alcohol test is a common method for testing heat stability of the milk proteins. This method consists of adding 70% alcohol to an equal volume of milk in a test tube (2 ml. of each) and then mixing vigorously. Coagulation indicates the milk is susceptible to coagulation during the heat treatment of sterilization.

Milk with sub-standard stability to the sterilization temperature may be improved with sodium citrate or Disodium phosphate at the rate of 30 gm to 170 gm. per 500 kg. of milk. Infrequently, the stability is restored by a calcium salt, e.g., calcium chloride.

Manufacturing Procedure

Standardization : The various steps involved in the manufacture of evaporated milk is given in **Figure No. 13.1**. Standardization of the milk fat to the solid-not-fat ratio is 1:2.5 for evaporated milk.

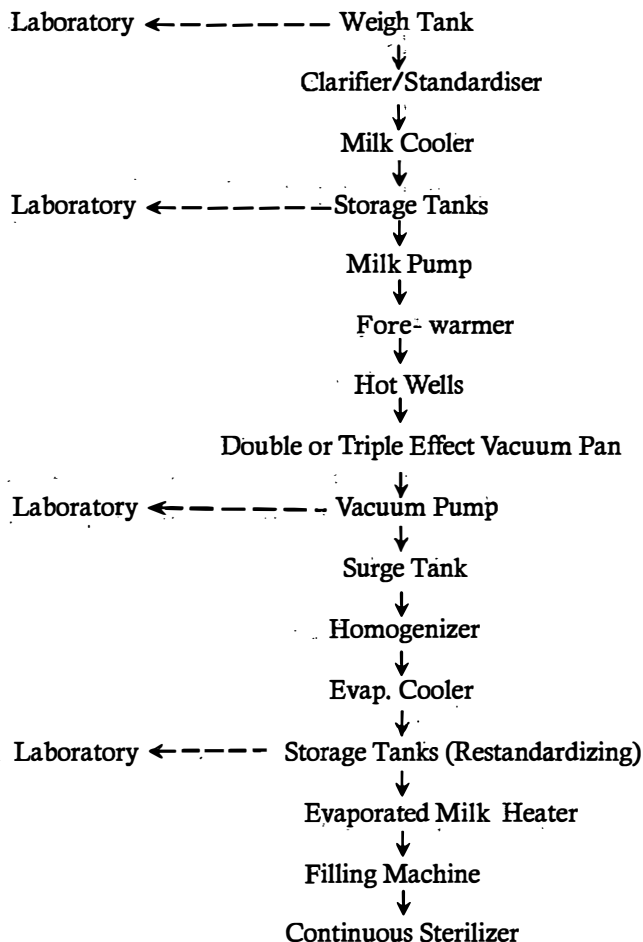


Fig. 13.1: Flow Diagram for an Evaporated Milk Plant

Clarification on Filtering and Preheating

Clarification of preheated milk may be done before or after standardization. Although not essential, it is a common practice in processing good quality evaporated milk. In some plants filtration of the milk is done instead of clarification. Purpose of preheating is mainly to improve stability against coagulation during sterilization, and to maintain a medium viscosity of the finished product. Preheating also increases the temperature of the milk for entry into the evaporator. Later, sterilization will complete the destruction of enzymes and microorganisms which was partially accomplished by the preheating. Temperature and time of preheating should be adjusted to a number of factors such as milk composition as influenced by seasons of the year and feeds, breed of cows, etc. The range of preheating temperature commonly is 95°C to 98°C for 10 to 20 mins. or 115° to 130°C for 1 to 6 mins. A combination of preheating in both ranges has also been practiced.

Evaporation of Moisture: Continuous evaporation follows preheating. The amount of moisture removal from the product is controlled by the determination of the total solids with a Baume hydrometer, or other instrumentation. A customary practice is to concentrate slightly more than desired in the final product, for greater ease of standardization later. The product is pumped continuously from evaporator to homogenizer.

Homogenization : Next important process is homogenization. Evaporated milk must be homogenized thoroughly to obtain a uniform fat emulsion and reduce separation of fat to a minimum during storage. A temperature and pressure combination is needed that will reduce the globules to less than 1μ in diameter. The temperature is usually about 50°C . as the product is removed from the last effect of the evaporator. It may go directly to the homogenizer or receive additional heating. A pressure of approximately 2000 to 3000 p.s.i., in combination with a sufficient temperature, will give the desired reduction in size of fat globules.

Re-standardization : After homogenization, the evaporated milk is cooled to 10°C .

solids by the addition of water, skim milk, condensed skim milk and/or homogenized cream. Optional fortification with vitamin D concentrate and also, the stabilizing salt may be added at this point if pilot tests indicate a need. A laboratory or pilot size sterilizer is used as a guide in determining the amount of stabilizer required. The amount changes with the change of seasons.

Canning: Packaging of evaporated milk is done in cans of tin coated sheet steel. The volumetric fillers depend on a uniform temperature and head pressure of product for accurate control of fill. Common fillers have 48 or 60 individual filling cells and each one can be adjusted for volume of evaporated milk into the can. One type of machine fills through a small hole in the top. The hole is then mechanically sealed with solder. Another type fills the can and the lid is sealed on to it. Leak detectors reject the occasional improperly sealed can. An instrument may be included in the line to automatically reject cans containing solder pellets in the product.

Sterilization: The cans are conveyed continuously through a retort for sterilization. During forward progress, the evaporated milk is heated rapidly to 115° to 118°C . with hot water and steam; held for 15 mins. and cooled with cold water to approximately 25° to 30°C . Both agitation of product by means of can movement, and careful temperature control during sterilizing are necessary to limit burn-on inside the can. Lightweight cans are removed automatically. The cans are usually batch sterilized in a retort, but equipment is now available for continuous sterilization of these two sizes. Cans should be dry before the application of the label by machine. Automatic casers fill the shipping cases and the product is moved to shipping area or storage.

Storage of Evaporated Milk

Changes in quality of evaporated milk during storage can be delayed by decreasing the temperature. Time also is a contributing factor. The trend in recent years has been to store evaporated milk below room temperature (5° to 15° C) requiring refrigerated storage. In maintaining freshness the lower the temperature the better, although freezing is detrimental to the body and texture. Commercial evaporated milk remains acceptable for two years if held below 15° C., but deteriorates rapidly above 20° C. The humidity should be low (below 50%) to inhibit deterioration of the metal cans and labels. Domestic cases should be limited to 12 high when they are stacked in storage. Removal from refrigerated storage should be by a system that prevents condensation of moisture on the containers.

Defects in Evaporated Milk

The principal defects occurring in freshly processed and stored evaporated milk are : (1) cooker flavour; (2) coagulation; (3) discolouration; (4) gelation or thickening ; (5) fat separation ; (6) staling ; (7) protein settling ; (8) mineral salt separation ; and (9) lack of sterility.

Heat Induced Flavour

The cooked flavour in evaporated milk is attributed to the liberation of sulfhydryl groups. They are caused primarily by the high temperature (115° to 118° C) and the time (15 mins.) required for sterilization. The heat induced effects of flavour are cumulative so the relatively slow heat-up period and cooling time add to the intensity of the cooked flavour. Preheat treatment may be useful but is relatively unimportant because of the much more pronounced influence of sterilization. UHT sterilization of the evaporated milk and aseptic packaging in sterilized cans reduces the cooked flavour substantially, but may introduce other problems such as higher percent of spoilage.

Heat Stability

Coagulation during sterilization may be prevented by pretesting the evaporated milk with pilot equipment and ascertaining a satisfactory corrective measure such as optimum preheat treatment for stability during sterilization. More rigid elimination of raw milk with acid development is a consideration, but minor changes in pH of the milk seem to have little effect on heat stability. Other considerations involve stricter application of the alcohol test or other stability tests and elimination of any milk supply that give an indication of protein coagulation. The heat stability of milk can be improved by controlling the temperature and time of preheating.

Off-Colour

Browning or discolouration is principally attributed to caramelization of lactose and the Maillard reaction. The raw milk supply will influence the colour change. Some

milks show much more colour change from sterilization than others. Normally, a colour change in evaporated milk is observed after ten months of storage unless the temperature is below 15°C. The deterioration of colour is rapid if the storage is 32°C. or more. In some seasons the milk is more susceptible to this change than others. The method of preheating and sterilizing is a factor influencing colour. Short high temperatures are preferable to long and lower temperatures for the least discolouration. Discolouration also increases with the amount of stabilizing salt.

Gelation

Viscosity of evaporated milks may differ and it is regulated mainly by heat treatment, agitation, storage temperature, and time. Too thin or too viscous a product is undesirable. Therefore, the preheating, and if possible the sterilizing temperature and time, are altered to obtain the desired creamy consistency. Excessive agitation during sterilization can be detrimental to optimum viscosity. Viscosity may decrease during the first few weeks of storage and then increase. Low temperature storage delays thickening and gelation.

Milk Fat Separation

One of the principal problems in the storage of evaporated milk is the separation of fat. The defect accelerates as the storage temperature increases. Any condition or processing treatment that results in below normal viscosity of the evaporated milk will augment fat separation during storage. But adequate homogenization delays fat separation.

Off-Flavour During Storage

Stale type of flavour development in evaporated milk is augmented by increasing the total heat treatment during manufacture. However, production of the cooked flavour at the same time will mask this off-flavour during the initial stages. Minimizing the severity of heating and decreasing the storage temperature are important means of delaying the occurrence of the stale type of off-flavour in evaporated milk.

Separation of Non-fat Milk Solids

The settling of protein and mineral salt in evaporated milk is reduced by inverting the cans periodically during storage. The case inversion required for separation of fat suffices also for the non-fat solids. By controlling the protein denaturation during preheating and sterilization, and by optimum homogenization, protein settling can be reduced or delayed.

Bacterial Spoilage

Failure to adequately sterilize evaporated milk by the in-can process is rare with modern equipment. Non-sterility is due almost exclusively to minuscule leaks. A defective container may permit contamination immediately subsequent to sterilization, but instruments in the processing line eliminate practically all these defective containers.

Growth of the spore formers in evaporated milk usually produces several sensory changes, for example, bitterness and fermented odours. If the percentage of spoilage becomes a problem, the first concern is to check the sterilization temperature and time to be sure they are within the intended operation range. Some attention may be given to the general sanitation of all equipment, and to low temperature holding of all unprocessed milk.

SWEETENED CONDENSED WHOLE MILK

Composition

The manufacturing steps of sweetened condensed whole milk are outlined. The main difference from the manufacture of evaporated milk is the addition of sugar instead of heat sterilization to prolong the keeping quality. Specifications for sweetened condensed milk require not less than 8.75% milk fat, 28.0% total milk solids, and sucrose to water ratio of 61.5% : 38.5%. Therefore, the composition of the end product is usually within 8.5 to 9.7% milk fat, 28.5 to 30.5% milk solids (7.3 to 8.0% protein, 10.1 to 11.0% lactose, 1.5 to 1.7% ash), and 43.5 to 44.8% sugar. In Fig. No. 13.2 shows Flow Diagram for a Condensed Milk Plant is given in **Figure No. 13.2**

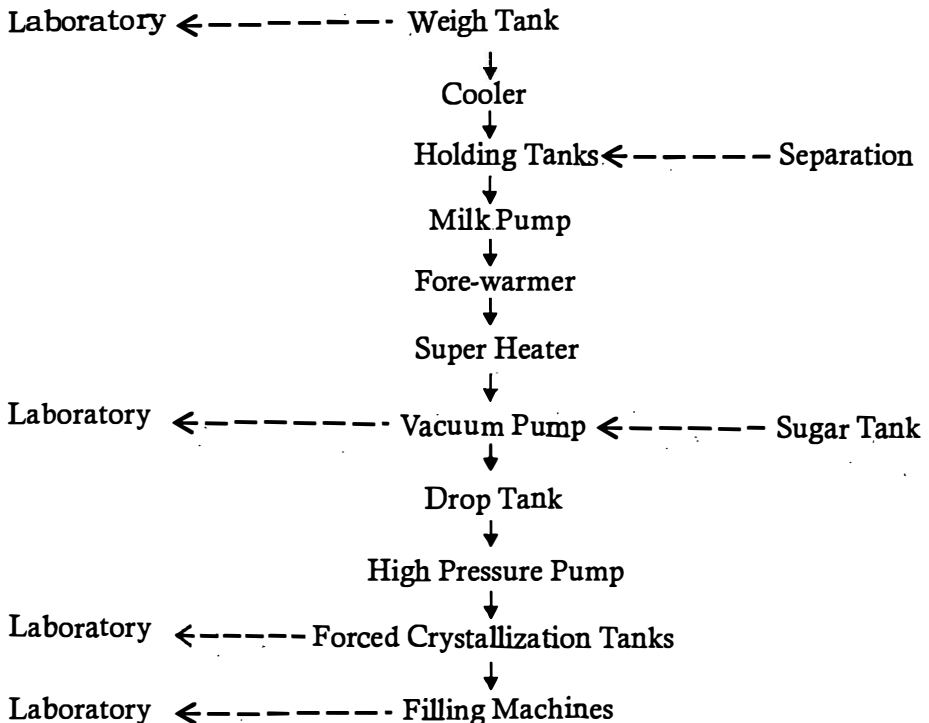


Fig. 13.2: Flow Diagram for A Condensed Milk Plant

Standardization and Preheating

Processing of sweetened condensed whole milk begins with good quality milk. It is standardized (fat to solids-not-fat of 1:2.294), clarified, preheated and may or may not be homogenized (60° C. to 70° C. and 1500 to 2500 p.s.i.). The preheating is continued upto a temperature of 180° to 200° C for 5 to 15 mins. or to 115° to 150° C for 30 sec. to 5 mins. by the UHT method. Effective pasteurization must be accomplished during heating to eliminate enzymes (such as lipase) and reduce the microbiological organisms to a low number. Oxidative changes also are delayed by the heat treatment. The exact temperature and time of heating is controlled to provide sufficient viscosity of the product without inducing excessive thickening during subsequent storage.

Concentrating the Solids

Condensing is accomplished by moving the product into a vacuum pan and operating with 25 to 28 inch or more of vacuum and sufficient steam for indirect heating to maintain vigorous boiling action. Condensing is complete when a slightly higher than 2:1 ratio has been attained. The Baume hydrometer is used to determine progress of condensing.

Addition of Sugar

Sugar is added at the end of the condensing step. If added before condensing an increase in viscosity and greater difficulty in evaporating the moisture are encountered. The amount of sugar required to inhibit bacterial growth is 43 to 45%. Sucrose in granulated or syrup form must be of good quality. The dry sugar is dissolved in minimum of water. Liquid sugars should be subjected to a high pasteurizing temperature to destroy the microorganisms before addition to the condensed milk. Care in the determination and addition of correct amounts of sugar for the milk solids is necessary for an efficient utilization.

After pumping from the vacuum pan the sweetened condensed whole milk is cooled to 30° C in a tubular cooler or another type of heat exchanger and held in a vat. The product may now be tested for total solids, sugar, and fat restandardized to whim a close tolerance.

Lactose Crystal Formation

Nuclei for crystallization are incorporated into the product by the addition of lactose in very fine powder form; pulverized nonfat dry milk; or sweetened condensed milk from a previous batch. If a powdered material is used, it should be capable of passing through a 200 mesh screen as an indication that the particles are sufficiently small. The lactose usage rate is about 100 gm. per 500 kg. of product. Twice as much nonfat dry milk is required when it is used as the "seed." A means of assuring uniform dispersion of the seed material is essential. One procedure consists of blending the "seed" into a small amount of condensed milk and then adding this to the batch during vigorous agitation. The agitation must continue while crystallization takes place to stimulate

the formation of numerous small crystals of lactose rather than fewer, but larger ones. Fast crystallization is conducive to the development of many crystals while slow crystallizing causes the large crystals which are responsible for sandy or gritty body and texture. Proper crystallization produces smooth body and texture as determined by sensory testing. After the “seed” is uniformly dispersed, cooling of the product may continue slowly to 25° C. This should take approximately an hour, then the cooling is completed to 12° to 18° C with continued agitation.

The rate of crystal formation is controlled by the amount of agitation, number of nuclei, total solids of the product, temperature, and the viscosity. A temperature decline can reduce the rate of crystallization by increasing viscosity; and at the same time increase the rate by increasing the degree of super-saturation of the lactose. An optimum temperature probably exists for each specific batch.

Packaging

The sweetened condensed milk is now ready for packaging. Bulk packaging may be in various size barrels, drums with polyethylene liners, or tin containers. Fillers are used to package sweetened condensed milk (12° to 18° C) in 420 gm. or other size cans for the retail market. After filling, cans are sealed, labeled, and packed in cases for storage and distribution.

Sanitation

Since sweetened condensed milk is not sterilized, special precaution after preheating must be exercised to prevent contamination, particularly of yeast and molds. This requires well cleaned sanitized equipment and special attention to each step in manufacturing to assure that contamination is not permitted. As a precaution the filling room is usually separate. Emphasis is given to a low level of air-borne microorganisms as well to the sanitation of the filling equipment. Cans and lids are treated with steam or a flame to a high heat and subsequently are protected as they move to the filler and the sealer.

Defects of Sweetened Condensed Milk

Sweetened condensed milk may have many of the same defects as described for evaporated milk: excessive viscosity, discolouration, chemical, and microbiological changes. Fat separation is a less serious problem in sweetened condensed milk. The intensity of the cooked flavour is usually not objectionable because of the omission of heat sterilization. The chief defects of sweetened condensed milk which warrant attention are: sandiness, sugar separation, and mold growth.

Sandiness

Numerous factors cause sandiness during manufacture and/or storage. Production causes may be one or more of the following: inadequate or improper seeding; product

temperature not controlled within desirable limits; lack of sufficient agitation during crystal formation; excessive amount of sucrose added to the condensed milk; high concentration of milk solids; too thin a viscosity and storage a wide temperature variation may increase the tendency to become sandy. A very low storage temperature such as 0° C or below is another cause of this problem.

Although the freezing point of sweetened condensed milk is approximately minus 15° C, the sugar saturation point may be lowered to the point that some sucrose also may crystallize and settle to the bottom of the container. Crystals of sucrose are sufficiently large to be observed by taste and sight.

The prevention of sandiness from lactose or sucrose necessitates satisfactory processing techniques and storage conditions to keep the lactose crystal size small and prevent sucrose crystals from forming.

Viscosity Changes

A standard viscosity of sweetened condensed milk to control sandiness is obtained by an optimum preheat treatment of the milk and to a much lesser extent by homogenization pressure (if used) and temperature adjustments. A cool storage is important too. If sugar is added prior to preheating and condensing the effect of the heat treatment on the protein stability is influenced. A higher concentration of total solids or lower pH increases the rate of thickening during storage.

Colour Changes

Microbiological changes in sweetened condensed milk are not necessarily prevented by the recommended sugar concentration. With increasing contamination in numbers and types of organisms the likelihood of growth and noticeable fermentative deterioration becomes greater.

Certain species of yeast and bacterial may produce gas, thicken the product as well as produce objectional sensory changes during growth in sweetened condensed milk. One of these gas producers is the yeast, *Torulopsis lactis-condensi*. Bacterial species in the following genera have grown in sweetened condensed milk: *Micrococcus*, *Streptococcus*, *Staphylococcus*, *Bacillus* and *Mycobacterium*. Coliform organisms have also been isolated from sweetened condensed milk. The heterogeneous contamination of microorganisms produce numerous undesirable flavour, changes-sour, cheesy, rancid, musty, fermented, yeasty, fruity, and others.

Control of microbiological deterioration consists of: effective pasteurization, low count sugar, and scrupulous sanitation of surroundings and equipment, including air (during filling and sealing). Sugar content of the aqueous phase of sweetened condensed milk must be not less than 61.5% and preferably 63.0 to 65.0%. Growth of aerobic microorganisms can be inhibited by vacuum packaging of the product.

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Chapter 14

Manufacture of Nonfat Dry Milk and Dry Whole Milk by Spray Process

Non fat Dry Milk and Dry Whole Milk are obtained by removal of water from cow milk or buffalo milk and suitably packed for long storage.

Equipment

The equipment for processing most dry milk products usually includes a separator, preheater, and/or high temperature short time pasteurizer with flow diversion valve, hot well evaporator, preheater, filler in concentrate line, high pressure pump and other pumps, drier with milk dust collector, cooler, sifter, and packaging equipment.

Separation

Separation of cream can be done with or without preheating the milk. Special cold milk separators are required for the low temperature method. Because fat separation of preheated milk usually is slightly more efficient, suggested temperature is between a range of 15° and 20°C if processing follows immediately. Otherwise if a holding period is involved, cold milk separation is more practical. The most important consideration regardless of method is a high degree of separation efficiency. Not more than 0.05% fat (Babcock method) should remain in the skim milk.

Preheating of Low-Heat Nonfat Dry Milk

Low-heat nonfat dry milk manufacture requires that heating be carefully controlled to result in a minimum amount of heat induced changes and yet accomplish proper pasteurization. Control of both time and temperature assumes much significance. High temperature short time pasteurization as a part of the preheating may be by tubular or plate heaters to not less than 72°C for at least 15 sec. Higher temperatures or longer holds contribute directly to whey protein denaturation. This index is used as a measure of the cumulative detrimental heat effects during processing of nonfat dry milk. Not more than 10% denaturation should occur.

Evaporation

Pasteurized skim milk is condensed continuously in an evaporator (or vacuum pan) to 40 to 48% T.S. The Baume hydrometer is used to test the total solid during condensing. An in-line refractometer may be used for continuous indication of the total solids. For a low-heat product the evaporator must be designed to operate efficiently with the

product temperature below that which causes the denaturation of the proteins. Some types of double and triple effect (or more) evaporators are not suitable for production of low-heat product. Therefore, necessary precaution must be taken to be sure that the design and operation of the double effect (or more) evaporator is satisfactory for low-heat product manufacture.

Desired level of total solids is obtained at the starting of the operation, the condensed skim milk is pumped continuously from the evaporator to a small balance tank. From there the condensed skim milk is pumped through a preheater to raise the temperature upto 60° to 65°C.

Spray Drying

The high pressure pump, usually of the piston type, forces the hot product through the spray nozzle into mist-like droplets in the drying chamber. The pressure of the pump ranges from about 1000 to 5000 p.s.i. depending on manifold conditions such as nozzle design and size, inlet and outlet air temperature, drying chamber characteristics, particle size and moisture content desired. Other types of spray nozzles are suitable for low pressure and one utilizes high velocity hot air to achieve atomization of the liquid. The flow diagram for manufacture of spray process Non fat Dry Milk and Dry Whole Milk is given in Figure No. 14.1.

Inlet air is heated by direct flame or steam coils to 200° to 250°C. Drying chamber design and subsequent equipment, as well as climatic conditions and desired moisture in the dry product, influence the inlet and exit air temperatures. The exhaust air temperature is the direct guide in controlling moisture of the product. But changes are achieved through adjustment of the inlet air temperature. The low-heat nonfat milk is dried to 3.0 to 4.0% moisture. Some driers have an auxiliary heater or redrier located after the primary drying chamber. These are useful when the air is humid or for enlarging the total drying capacity of the equipment.

Dry product Removal, Cooling and Sifting

Most milk driers have continuous removal system to immediately separate the dry product from the hot air stream which has been reduced to the range of approximately 80° to 90°C. The dry product should be cooled at once to approximately 32° to 35°C. A few plants still depend upon ambient conditions for cooling. Without cooling equipment, the temperature decline by natural means may be slow. During warm weather and with common warehousing practices of close, high stacks, temperature drop may involve several days with the accompanying product deterioration. Nonfat dry milk packaged too hot may become lumpy due to "heat-caking" and the development of an off-flavour and an off-colour during storage is much rapid.

A 25-mesh screen with No. 36 wire gauge (0.707 mm. sieve opening) is commonly used for sifting nonfat dry milk before packaging. Sifting is needed to remove lumps that are occasionally formed from a defective spray.

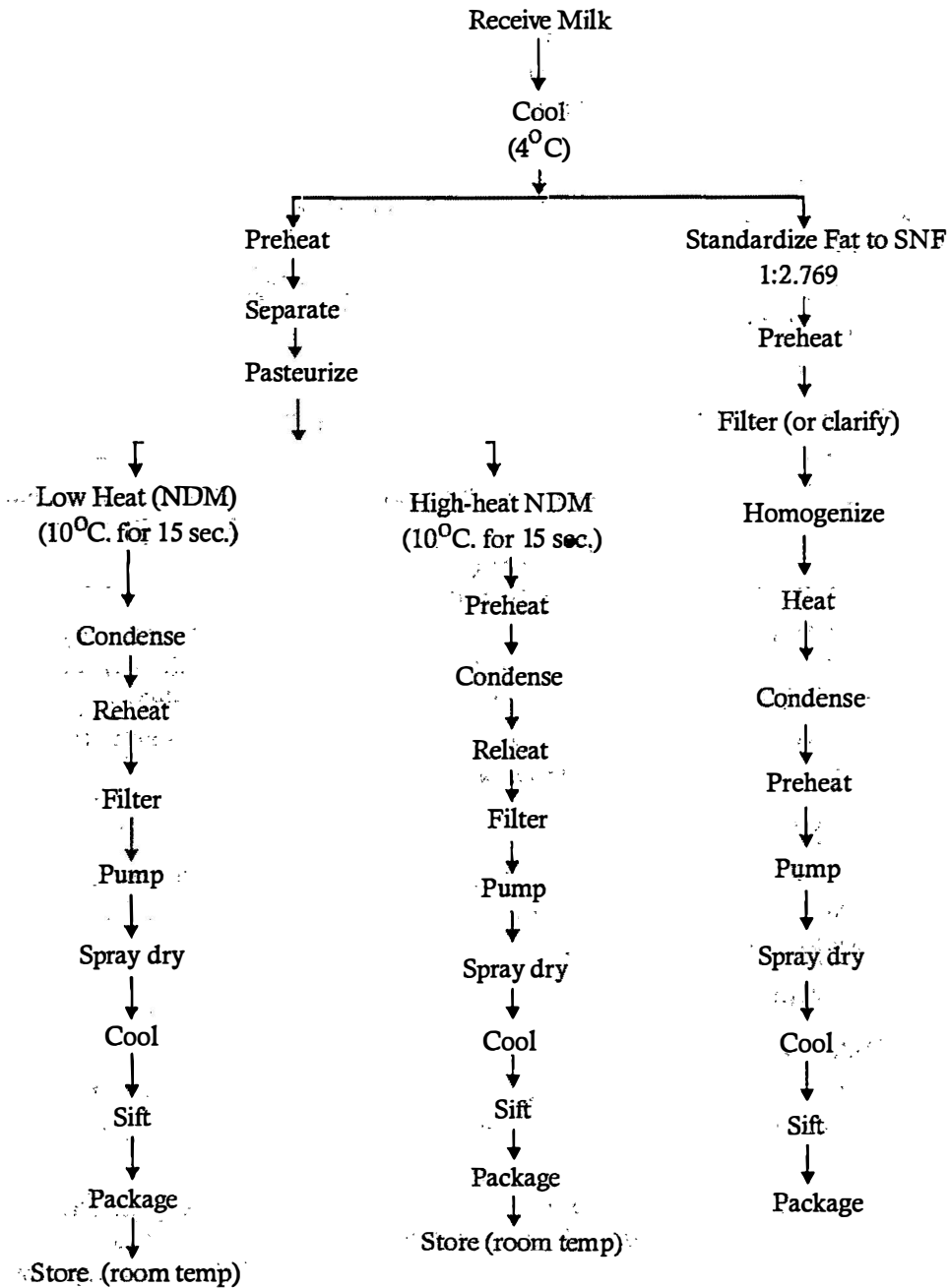


Fig. 14.1: Flow Diagram for Manufacture of Spray Process Nonfat Dry Milk and Dry Whole Milk

Preheating for High-Heat Nonfat Dry Milk

Except for the total treatment before drying the manufacture of high-heat nonfat dry milk is the same as for the low-heat product. In processing high-heat nonfat dry milk, care must be exercised to subject the skim milk to a time-temperature treatment that will impart good bread baking qualities to the nonfat dry milk. During the heat treatment the whey, protein is denatured. A test for the whey protein nitrogen is used as an index of the suitability of the dry milk for bread. Nonfat dry milk should contain no more than 1.5 mg. per gm. for use in bread formulas.

The heat treatment usually is applied to skim milk directly following pasteurization. The general practice is to heat the skim milk to 85° to 90° C.

Condensing and Spray Drying

The condensing step parallels the one used for the low-heat product, except the evaporator is operated for maximum efficiency without concerns about serum protein denaturation. The reheating of the condensed milk ahead of the high pressure pump may be higher than for low-heat nonfat dry milk. Temperature of condensed milk may be elevated to 70° to 75°C or higher. A high temperature improves efficiency, but is limited by several conditions. The temperature must be maintained below the level where casein denaturation will cause a high solubility index (insoluble sediment when the dry milk is reconstituted). The specific temperature at which the increase solubility index affects the grade of the dry milk is dependent upon heat stability of the milk, the preheat treatment and the time lapse necessary to allow the condensed milk to flow from the heater outlet through the high pressure pump to the spray nozzle.

Moisture Control

The pump pressure ordinarily is within 1500 to 5000 p.s.i. with the outlet air drying temperature usually between 75° and 95°C. The final moisture in the high-heat nonfat dry milk is controlled to approximately three to four percent.

DRY WHOLE MILK

Manufacture by Spray Process

The manufacture of dry whole milk is not much different from nonfat dry milk. Since keeping quality is restricting factor, care should be taken to obtain the maximum storage life.

The milk fat is standardized in ratio of the solids-not-fat so that the dry product will meet the standard of not less than 26% fat. This requires a fat content of 3.2 % assuming the solids-not-fat is 8.86%. Some milk is standardized to have 28% fat in the dry form.

Homogenization of the whole milk is common if direct reconstitution of the dry whole milk is contemplated. Without homogenization the fat may churn during agitation while combining with water. Another advantage of homogenization is the

improvement of keeping quality. The fat globules, although smaller, are more thoroughly recovered with the protein membrane. A pressure of 2500 to 3500 p.s.i. at 60° and 70° C provides sufficient homogenization.

Numerous optimum temperature-time conditions have been used in preheating whole milk. When sufficient solids concentration has been attained (35 to 45%) product is continuously removed from the evaporator.

The temperature of condensed milk after it is pumped from the evaporator is boosted to 60° to 70°C in a heat exchanger prior to the high pressure pump. The condensed milk is dried with inlet air at 150° to 250°C and exit air at 70° to 95°C depending upon drier characteristics. To reduce heat damage during the dehydration, and yet obtain the desired moisture, a low exhaust air temperature is preferred.

The dry whole milk should be immediately removed from the hot air stream to maintain better body characteristics and keeping quality. The higher the temperature and the longer the time the product is above the melting point of the fat the greater the amount of free fat that results.

The use of refrigerated air to move the dry whole milk to a cyclone after it leaves the drying chamber is one system of decreasing the temperature. Cooling to room temperature is preferred.

A 12- mesh screen is used for sifting dry whole milk. The product should be packaged immediately or held under a vacuum for 7 to 10 days before gas packaging (described later).

Modern Process of Milk Powders

Production of spray dried milk powder consists of two phases, in the first phase milk is evaporated under vacuum to a dry matter content of about 45 – 55%. In the second phase the concentrate is pumped in to a drying tower for final drying. This process takes place in three stages:

- Dispersion of the concentrate into very fine droplets.
- Mixing of the final dispersed concentrate into a stream of hot air which quickly evaporates the water.
- Separation of the dry milk particles from the drying air.

Falling film evaporators are generally used for concentration, which is carried out in two or more stages to concentrate solids content of 45 – 55 %.

Spray dried skim milk powder is manufactured in two basic qualities:

- Ordinary product and,
- Agglomerated product (instant milk powder) by various spray drying systems.

Production of Instant Powder

Milk powder which will dissolve quickly in water must be instantised, i.e., the milk particles must be treated so that they form large, porous agglomerates. To obtain the correct porosity the milk particles must first be dried so that most of the water in the

capillaries and porosity is replaced by air. The particles must be humidified, so that the surfaces of the particles swell quickly, closing the capillaries. The surfaces of the particles will then become sticky and the particles will adhere to form agglomerates.

Single Stage Drying: This system works on the single stage drying principle, which means that all removal of moisture from the concentrate to the required final moisture content takes place in the spray drying chamber.

During the drying process the milk powder settles in the drying chamber and is discharged at the bottom. It is conveyed pneumatically to the packing section by cooling air which is drawn into the conveyor duct by a fan. After cooling, the mixture of cooling air and powder flows to the discharge unit, where the powder is separated from the air before being packed.

Some small light particles may be mixed with the air that leaves the drying chamber. This powder is separated in one or more cyclones. After separation the powder is returned to the main stream of milk powder on the way to packing. The cleaned drying air is extracted from the plant by a fan.

Two Stage Drying: In a two stage drying system producing the same type of powder as the previously mentioned installation, the pneumatic conveying system is replaced by fluid bed dryer. Two-stage drying methods for producing powder milk product combine spray drying as the first stage and fluid bed drying as the second stage. The moisture content of the powder leaving the chamber is 2–3 percent higher than the final moisture content. The function of the fluid bed dryer is to remove excess moisture and finally to cool the powder down.

The powder from both single stage and two stage installations consists predominantly of single particles, it is dusty and difficult to reconstitute. There are, however, some slight differences. Two stage dried powder is coarse due to bigger primary particles and the presence of some agglomerates. Consequently it is not so dusty and can be reconstituted more easily. However the biggest difference between these two powders is in the properties that are influenced by heat exposure during drying.

Fluid Bed Drying

More efficient instantisation can be obtained with a fluid bed. The fluid bed is connected to the bottom of the drying chamber and consists of a casing with a perforated bottom. The casing is spring mounted and can be vibrated by a motor. When a layer of powder is distributed on the perforated bottom, the vibrations convey the powder at uniform speed along the length of the casing.

The powder from the drying chamber is admitted to the first section, where it is humidified by steam. The vibrations convey the powder through the drying sections, where air at a gradually decreasing temperature is admitted through the powder bed. Agglomeration takes place in the first stage of drying when the particles adhere to each other. Water is evaporated from the agglomerates during their passage through the

drying sections. They will have attained the required dryness when they have passed through the fluid bed casing.

Any larger particles at the outlet of the dry bed are screened and recirculated to the inlet. The screened and instantised particles are conveyed by the cooling air to a battery of cyclones, where they are separated from the air and packaged.

The drying air from the fluid bed, together with air from the spray tower, is then blown to the cyclone for recovery of milk particles.

Three Stage Drying: Three stage drying is an extension of the two stage concept developed to achieve even greater savings in plant operation costs.

The three stage dryer involves transfer of the second drying stage into the base of the spray drying chamber and having the final drying and cooling conducted in the third stage located outside the drying chamber. There are two main types of three-stage dryers:

1. Spray dryers with integrated fluid bed.
2. Spray dryers with intergrated belt.

The Success of the instantizing operation depends on the following factors

- i. Uniform and constant rate of powder distribution into the wetting zone.
- ii. Avoiding over-or under-wetting of particles by providing uniform moisture conditions. (Over-wetted particles dissolve slowly and inadequate wetting permits excessive shattering during handling).
- iii. Stabilizing air movement to ensure optimum particle collision. (Excess movement causes the product to adhere to the equipment lining).
- iv. Controlling redrying air temperature and flow rate (which is necessary for adequate moisture removal without heat-damage to the instantized product).

FACTORS AFFECTING THE BULK DENSITY:

The packed bulk density of nonfat dry milk has a wide range of 0.18 to 1.25 gm. per ml, but for regular spray dried milk generally it is 0.50 to 0.60 gm. per ml and drum dried nonfat dry milk it is 0.30 to 0.50 gm. The manufacturing procedure and conditions greatly influence bulk densities, principally by the effect on air content. Obviously steps to reduce the entrapped air will increase the density. One means is to minimize the air content of the concentrate before drying. Increasing the total solids of the concentrate, reducing the spray pressure, and using a large orifice increases the bulk density. The Production of Instant Whole Milk Powder is given in figure No. 14.2

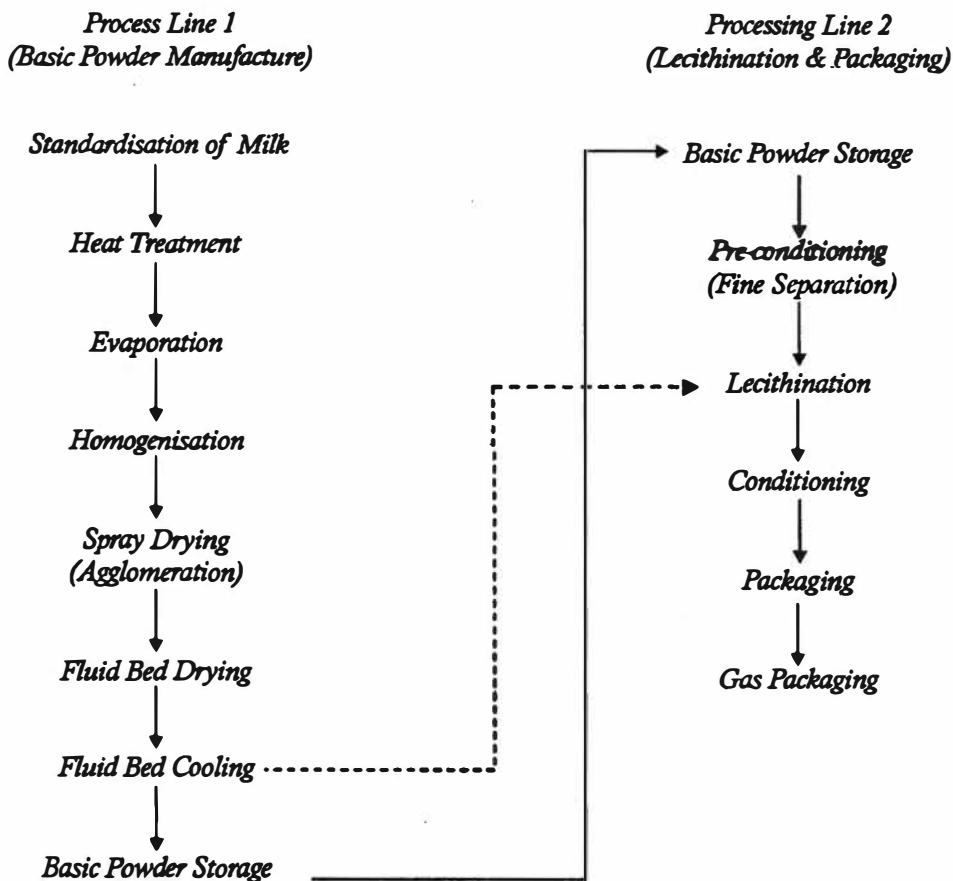


Fig. 14.2 Flow Diagram for Production of Instant Whole Milk Powder
(The single – line process shown by dotted line)

FACTORS AFFECTING THE QUALITY OF INSTANT POWDER

Factors	Possible Effects	Suggested Normal Range
a) Quality of Initial dried milk used		
1. Type of powder i.e., grade of powder	Better physical strength and less shattering with low heat powder	Low-heat powder (WPNI > 6.0 mg/g preferred)
2. Fat content	High fat leads to poor agglomeration And high free fat in the finished product	Low fat content in powder desirable
3. Solubility	Good solubility powder yields instant powder with minimum solubility index	Powder should have minimum solubility index (>1.0)
4. Particle density	Agglomerate density and sinkability of instant powder increase with Increased particle density	Powder with high particle density recommended

5. Particle size	Influences the size of agglomerates formed	25 – 50 μ size
6. Storage period of Powder	Static electricity and less bulk density of fresh powder adversely affect agglomeration	Powder should be at least 24 hrs old
b) Condition in re-wet process during agglomeration and re-drying		
1. Re-wetting moisture content	Properties like agglomeration, dispersibility, sinkability, solubility index, bulk density and porosity Are adversely affected if moisture content is not optimum	Optimum moisture varies between 12-15 %
2. Size of agglomerate	Both poor agglomeration and over agglomeration impairs the dispersibility	Around 200 μ is optimum (range 180-840 μ)
3. Temperature of feeding	Very little effect on dispersibility	-
4. Temperature of final drying	High temperatures of drying decrease the solubility	Will depend on the design of the equipment. However, it must be consistent with final moisture content and solubility of the resultant powder

* (WPNI : Whey Protein Nitrogen Index)

BIS SPECIFICATION FOR SKIMMED MILK POWDER EXTRA GRADE

Sr. No.	Characteristic	Requirement
1.	Moisture, percent by mass, Max	3.5
2.	Total solids (milk solids and added salts), percent by mass, Min	96.5
3.	Milk fat, percent by mass, Max	1.25
4.	Insolubility index, ml, Max	0.5
5.	Total ash (on dry basis) percent by mass, Max	8.2
6.	Titration acidity (as lactic acid) percent by mass, Max	1.5
7.	Lactate content, mg/g, Max	1.5
8.	Scorched particles, Max	15 mg (equivalent to Disc B)

BIS SPECIFICATION FOR SKIMMED MILK POWDER STANDARD GRADE

Sr. No.	Characteristic	Requirement
1.	Moisture, percent by mass, Max	4.0
2.	Total solids (milk solids and added salts), percent by mass, Min	96.0
3.	Milk fat, percent by mass, Max	1.5
4.	Insolubility index, ml, Max	
	a) Roller dried	15.0
	b) Spray dried	1.5
5.	Total ash (on dry basis) percent by mass, Max	8.2
6.	Titration acidity (as lactic acid), percent by mass, Max	1.5

PRODUCT SPECIFICATION FOR WHOLE MILK POWDER ADPI – EXTRA GRADE

1. Physical:

Colour	Light Cream
Flavour	Pleasant & Clean
Odour	Clean

2. Chemical:

Moisture percent by mass,	Max.	4.5
Total Solids (milk solids & added salts) percent by mass,	Min.	95.5
Fat, percent by mass,	Min.	26.0
Insolubility Index,	Max.	1.0 ml
Titration Acidity percent ADPI – Method	Max.	0.15
Scorched Particles /25 gm		Disc – B (15 mg)
Total Protein percent by mass	Min.	26.0

3. Microbiological:

Standard Plate Count / gm	≤ 50000
Coliform / gm	10

PRODUCT SPECIFICATION FOR SKIMMED MILK POWDER ADPI – EXTRA GRADE (LOW HEAT, MEDIUM HEAT & HIGH HEAT)

1. Physical:

Colour	Creamy
Flavour	Pleasant & Clean
Odour	Clean

2. Chemical:

Moisture content percent	Max.	4.00
Insoluble Index, ml	Max.	1.25
Fat percent	Max.	1.25
Titration Acidity Percent, (ADPI-Method)	Max.	0.15
Scorched Particles /25 gm		15.0 mg (Disc – B)
Protein percent by mass	Min.	36
Ash percent by mass	Max.	8.2
WPNI For Low Heat		Not less than 6.0 mg/gm
For Medium Heat		1.51 – 5.99 mg/gm
For High Heat		Not more than 1.5 mg/gm

3. Microbiological:

Standard Plate Count / gm	≤ 50000
Coliform / gm	≤ 10
E.coli / 50 gm	Absent
Staphylococcus aureus / 11 gm	Absent
Salmonella / 50 gm	Absent
Listeria / gm	Absent

BIS SPECIFICATION FOR WHOLE MILK POWDER

Sr.No.	Characteristic	Requirement
1.	Moisture, percent by mass, Max	4.0
2.	Total solids (milk solids and added salts), percent by mass, Min	96.0
3.	Milk fat, percent by mass, Min	26.0
4.	Insolubility index, ml, Max	2.0
5.	Total ash (on dry basis) percent by mass, Max	7.3
6.	Titration acidity (as lactic acid), percent by mass, Max	1.2

HEAT - TREATMENT CLASSIFICATION OF SKIMMILK POWDER

Heat-treatment classification is not a grading requirement, but is of practical importance in indicating the suitability of spray dried skim milk powder for various uses. Heat treatment denatures whey proteins, the percentage denatured increasing with the intensity of heat treatment. The degree of denaturation is normally expressed by the Whey Protein Nitrogen Index (WPNI) as milligrams of undenatured whey protein (u.w-p) per gram of powder.

Categories of Spray Dried Skimmilk Powder.

Category	Temp/time	WPNI mg/g u.w-p
Extra low-heat	< 70°C	*
Low-heat (LH) powder	70°C / 15 s	> 6.0
Medium-heat (MH) powder	85°C / 20 s	5 - 6.0
Medium-heat (MH) powder	90°C / 30 s	4 - 5.0
Medium-heat (MH) powder	95°C / 30 s	3 - 4.0
Medium high – heat (HH)	124°C / 30 s	1.5 – 2.0
High-heat (HH)	appr. 135°C / 30 s	< 1.4
High-heat high stable (HHHS) (from selected milk)	appr. 135°C / 30 s	< 1.4

* Not measurable, S- Seconds

PRODUCT SPECIFICATION FOR INSTANT MILK POWDER**1. Physical:**

Colour	Light Cream
Flavour	Pleasant
Odour	Clean
Texture	Granular, Free from lumps

2. Chemical:

Moisture percent by mass,	Max.	4.5
Total Solids %	Min.	95.5
Fat, percent by mass,	Min.	26.0
Insolubility Index, ml	Max.	0.50
Titration Acidity percent ADPI – Method	Max.	0.15
Scorched Particles	Max.	Disc – B (15 mg)
Total Protein percent by mass	Min.	26.0
Wettability	Time.	10 Sec.

3. Microbiological:

Standard Plate Count / gm	Max.	30000
Coliform / gm	Max.	10
Yeast & Mold / gm		Absent
E.Coli- / gm		Absent
Staphylococcus aureus / gm		Absent
Salmonella / 375 gm		Absent

4. Packaging

25 kg packed in food grade polythene bag of 0.050 mm thickness. The bag closed by heat sealing. Subsequently polythene bags are encased in stitched Kraft paper bags made out of Kraft paper.

5. Storage: Storage at cool and dry place.**Approximate Composition and Food Value for Dry Milks**

Constitutes	SMP	WMP	Butter milk Powder
Protein (N x 6.38) %	36.0	26.0	34.0
Lactose (Milk Sugar) %	51.0	38.0	48.0
Fat%	0.7	26.75	5.0
Moisture %	3.0	2.25	3.0
Minerals (Ash) %	8.2	6.0	7.9
Calcium %	(1.31)	(0.97)	(1.3)
Phosphorus %	(1.02)	(0.75)	(1.0)
Vitamin A (I.U./lb)	165.0	4950.0	2300.0
Riboflavin (mg/lb)	9.2	6.7	14.0
Thiamine (mg/lb)	1.6	1.2	1.2
Niacin (mg/lb)	4.2	3.1	4.5
Niacin Equivalents* (mg/lb)	42.2	30.6	40.6
Pantothenic Acid (mg/lb)	15.0	13.0	14.0
Biotin (mg/lb)	0.2	0.2	0.2
Choline (mg/lb)	500.0	400.0	500.0
Energy (Calories /lb)	1630.0	2260.0	1700.0

* Includes contribution of tryptophan

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Chapter 15

Manufacturing of Ice Cream

Ice cream is a delicious, wholesome, nutritious frozen dairy food. It is made of pure sweet cream, milk, skim milk, condensed milk or other concentrated dairy products, or combination of these, plus added sugar and flavoring, with or without stabilizer or colour, and with the incorporation of air during the freezing process. No other food product contributes so much food value in an attractive and appealing form, or is so universally liked and distributed, as ice cream.

Some of the factors which have contributed to the recent development of the ice cream industry are:

1. The perfection of mechanical refrigeration and its application to the food industry.
2. Improved manufacturing methods and equipment such as the homogenizer, over-run testers, continuous freezers, packaging machines, etc.
3. More and better ingredients and more knowledge concerning ice cream making, resulting in a better product.
4. Lower manufacturing costs through mass production.
5. Extensive advertising of the product.
6. A realisation of the high food value of ice cream.
7. Changing economic condition-better wages, more purchasing power, a higher standard of living.
8. Improved storage facilities for ice cream in the home.

Ice Cream Industry in India

India has one of the lowest per capita consumption globally, at about 250 ml per annum. In contrast, in USA it is 22.5 litres per annum and in many developing countries it ranges from 1 to 10 litres. The Indian ice-cream market is valued at Rs. 250 crore (branded and unbranded), and expected to grow at the rate of 20 percent a year. Competing in the ice cream market at present are an estimated 150 players of the organized sector (60 percent market share) and over 2,000 units in the non-organized sector (40 percent share). The growth rate could have been even higher but for poor infrastructure, high excise duty of 16%, sales tax of 15.10% in most of the states and high import duties on cocoa products, flavours, etc., leading to low margins and poor returns in the Ice cream business.

Ice creams are available in various forms such as cone, cups, bar (candy), party pack etc. Candysticks account for about 25-30% of volumes, whereas cups and other novelties contribute the rest. The market is totally dominated by Vanilla, Strawberry and Chocolate, which combinedly account for more than 70% of the market followed by butterscotch and other fruit flavours. Popularisation of thick milk shakes, softy mixes, sherbets, syrups and special toppings for ice creams by the ice cream parlours and fast food joints opens a new business prospect.

Food Value

Ice cream is an excellent source of food energy. It contains 3 to 4 times as much fat, and about 12 to 16 percent more proteins than milk. In addition it contains other food products such as fruits, nuts, chocolate and sugar which enhance its nutritive value. One serve of good average composition of vanilla ice cream (100 ml) supplies approximately 200 cal, 3.9 gm proteins, 0.31 gm calcium, 0.140 gm phosphorus, 0.14 mg iron, 548 IU vitamins A, 0.038 mg thiamine and 0.236 mg riboflavin.

Composition of Ice cream

Today's ice cream has the following composition : a) greater than 10% milkfat by legal definition, and usually between 10% and as high as 16% fat in some premium ice creams; b) between 10 and 12% milk solids-not-fat, the component which contains the proteins (caseins and whey proteins) and carbohydrates (lactose) found in milk; c) 12% to 15% sweeteners, usually a combination of sucrose and glucose-based corn syrup sweeteners; and d) 0.3% to 0.5% added stabilizers and emulsifiers. The balance, usually 55% to 64%, is water which comes from the milk.

Classification of Ice Cream

Classification of Ice Cream has been attempted by various authors of ice cream text books and leading authorities in the industry from time to time, but as yet no standard classification has been adopted. The innumerable variations in the composition of ice cream, in the ingredients and the methods of using them, and in the forms in which the finished product is marketed are the source of much confusion in any attempt to make specific rules for definite classes of ice cream.

Plain Ice Cream: An ice cream in which the colour and flavouring ingredients together amount to less than 5 percent of the volume of the unfrozen ice cream. Examples are vanilla, coffee, maple and caramel ice cream.

Chocolate: Ice cream flavoured with cocoa or chocolate.

Fruit: Ice cream containing fruits, with or without additional fruit flavouring or colour. Fruits such as strawberry, apricot, pineapple, mango, banana, etc., may be fresh, frozen-packed, canned or preserved.

Nut: Ice cream containing nuts, such as almonds, pistachio, walnuts, cashewnut, etc., with or without additional flavouring or colour.

Milk Ices or Milk Lollies: According to the FSSAI rules these refer to the frozen product obtained from milk, skim milk or milk products with or without the addition of cane sugar, fruits, fruit juices, nuts, chocolate, edible flavours, and permitted food colours. It may contain permitted stabilizers not exceeding 0.5 percent of the product. The mixture should be suitably heat-treated before freezing. The product should contain not more than 2.0 percent milk fat, not less than 3.5 percent proteins and not less than 20.0 percent total solids.

Ices: Made of fruit juice, sugar and stabilizers, with or without additional fruit, colour, flavouring or water, and frozen to the consistency of ice cream. Usually contain 28 to 30 percent sugar, 20 to 25 percent overrun and no dairy products.

Fruit Sherbet: Made of fruit juices, sugar, stabilizer, and milk products. It is similar to an ice except that milk, either whole, skim, condensed or powdered, or ice cream mix, are used; in stead of all part of the water in an ice.

Fancy Moulded: Moulded in fancy shapes and composed either of one colour and flavour of ice cream or combination of colours and flavours, or especially decorated. Examples are: brick ice cream, cakes, cake roll, moulds representing fruits, etc.

Novelties: A novelty ice cream or frozen confection is an especially shaped and usually a low priced package containing an individual serving whose main appeal consists its shape, size, colour or convenience for eating.

Soft Ice Cream: Popularly known as Softy is drawn from the freezer without hardening and sold. Softy is short for 'soft-serve frozen desert'.

FSSAI Standards:

FSSAI standard for Ice Cream, Kulfi and Chocolate Ice Cream:

The frozen product obtained from cow or buffalo milk or a combination thereof or from cream, and/or other milk products, with or without the addition of cane sugar, dextrose, liquid glucose and dried liquid glucose, eggs, fruits, fruit juices, preserved fruits, nuts, chocolate, edible flavours and permitted food colours. It may contain permitted stabilizers and emulsifiers not exceeding 0.5 percent by weight. The mixture shall be suitably heated before freezing. The product shall contain not less than 10.0 percent milk fat, 3.5 percent protein and 36.0 percent total solids except that when any of the aforesaid preparations contain fruits or nuts or both, the content of milk fat shall not be less than 8.0 percent by weight. Starch may be added to a maximum extent of 5.0 percent under a declaration on the label as specified in sub-rule (2) of Rule 43. The standards for ice cream shall also apply to softy ice cream, where the chocolate or like covering portion forms a separate layer, only the ice cream portion shall conform to the standards of ice cream.

FSSA Standard for Milk Ices or Milk Lollies:

The frozen product obtained from milk, skimmed milk, or milk product with or without the addition of cane sugar, dextrose, liquid glucose and dried liquid glucose, eggs, fruits, juices, nuts, chocolate, edible flavours and permitted food colours. It may contain permitted stabilizers not exceeding 0.5 percent of the product. The mixture shall be suitably heat-treated before freezing. The product shall contain not more than 2.0 percent milk fat, not less than 3.5 percent proteins and not less than 20.0 percent total solids.

FSSA Standard for Dried Ice Cream Mix:

The product obtained from the material prepared by spray or roller drying of ice cream mix shall contain milk solids, sucrose or corn syrup or refined sugar. It may contain permitted colours and flavours. It may contain stabilizers and emulsifiers not exceeding 1.25 percent by weight. The product shall contain not less than 27.0 percent milk fat and 9.5 percent protein and moisture shall not be more than 4 percent by weight. The sucrose content shall be not more than 40 percent, by weight. The process of drying shall be mentioned on label. It shall be packed in hermetically sealed clean sound container.

Sanitation and Hygiene In Ice Cream Manufacturing & Handling

A high quality ice cream can be made only from high quality ingredients mixed in balanced proportions and adopting strict sanitary control during various processing operations and distribution. Any relaxation in exercising such control measures may render this nutritious product a potential health hazard. Although the quality of ice cream is usually judged by its flavour, body and texture, melting quality, package, colour and keeping quality characteristics, it is the bacterial content that plays an important role in determining its sanitary quality.

Table 15.1: BIS Specification of Ice Cream

Characteristic	Requirement
Weight (gm/litre) min	525
Total solids (% wt.) min	36.0
Milk fat (% wt) min	10.0
Acidity (% lactic acid) max	0.25
Sucrose (% wt) max	15.0
Stabilizer/Emulsifier (% wt) max	0.5
Standard plate count (per gm)	Not more than 2,50,000
Coliform count (per gm)	Not more than 90
Phosphatase test	Negative

Bacteriological Standards Recommended by BIS for Ice Cream and Other Ingredients.

Ingredients	SPC Max/g	Coliform Max/g
Ice Cream	2,50,000	90
Cream Pasteurised	60,000	10
Condensed milk	500	Negative
Dry milk	50,000	Negative

The Manufacturing Process

The basic steps in the manufacturing of high quality ice cream are good blending of the mix ingredients together with pasteurization, homogenization, aging the mix, freezing, packaging, and hardening. The Flow Diagram for Manufacture of Ice Cream is given in figure No. 15.1

Selection of Ingredients for Making the Mix

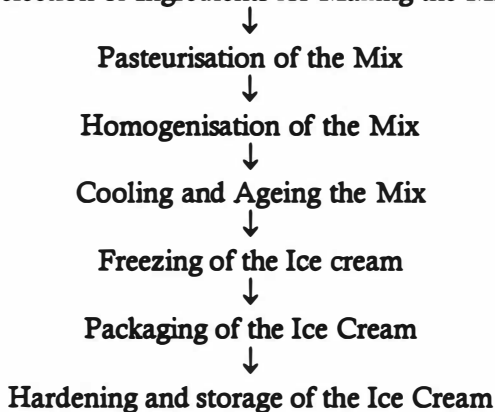


Fig. 15.1: Flow Diagram for Manufacturing of Ice Cream

Selection of Ingredients for Making the Mix

In order to manufacture good quality ice cream, ingredients are selected based on the desired formulation and the calculation of the recipe from the formulation and the ingredients chosen, and then the ingredients are weighed and blended together to produce what is known as the “ice cream mix”. Blending requires rapid agitation to incorporate powders, and often high speed blenders are used. Ingredients are chosen by the manufacturer on the basis of desired quality, availability and cost. The mix should be properly balanced. A balanced mix is one in which the proportion of the constituents and ingredients is as such which will produce a fine and generally satisfactory ice cream.

Pasteurization

Proper pasteurization of the mix is compulsory because this process destroys all pathogenic or disease-producing bacteria, thereby safeguarding the health of the

Homogenization

Homogenization of the ice cream mix is essential. After homogenization the fat emulsion in Ice cream mix is broken down to less than 2 microns. Two stage homogenization is usually preferred for Ice cream mix. A pressure of 150 bar on the first stage and 30 bar on the second stage should be satisfactory under most conditions.

Aging

After pasteurization and homogenization the mix is immediately cooled and held in aging tank for at least four hours. Aging helps the fat to cool down and crystallize, and for the proteins and polysaccharides to fully hydrate. Aging the mix before freezing has been practiced since the inception of the ice cream industry.

Aging provides the following results:

- Improves whipping qualities of mix and body and texture of ice cream.
- Increases maximum overrun.
- Increases melting resistance.

Freezing

After proper aging, the mix is drawn into a flavour tank where any liquid flavours, fruit purees, or colours are added. Freezing is most important process in the manufacturing of Ice cream for upon it depends the quality, palatability and yield of the Ice cream. There are three types of freezers, Batch type freezer, Continuous freezer and Soft serve freezer. The freezer is a scraped-surface, tubular heat exchanger, which is jacketed with a boiling refrigerant such as ammonia or freon. Mix is pumped through this freezer and is drawn off in a matter of 30 seconds, (or 10 to 15 minutes in the case of batch freezers) with about 50% of its water frozen. There are rotating blades inside the barrel that keep the ice scraped off the surface of the freezer and also dashers inside the machine which help to whip the mix and incorporate air. As the Ice cream is drawn with about half of its water frozen, particulate matter such as fruits, nuts, candy, cookies, or whatever you like, is added to the semi-frozen slurry which has a consistency similar to soft-serve Ice cream. In fact, almost the only thing which differentiates hard frozen ice cream from soft-serve, is the fact that soft serve is drawn into cones at this point in the process rather than into packages for subsequent hardening.

Packaging

After freezing, the Ice cream is collected in containers which give it the desired shape and size for convenient handling during the hardening and marketing process. The single service type of package has met with increasing favor. The rapid improvement of roads, delivery trucks, and mechanically refrigerated cabinets, as well as wide use of continuous freezers and automatic packaging machines, has hastened the increasing use of single-service containers. These packages are constructed of paper, card-board

and plastic. The volume of ice-cream packaged in the various carton sizes depends upon the type of market outlet and local consumer buying practices.

Hardening & Storage

The packed ice cream is placed into a blast freezer or Harding room at -30° to -40° C where most of the remainder of the water is frozen. The hardening time may be as short as 30 minutes for a 100 ml cups or as long as 24 hrs for a 4 litres pack. Below about -25° C, ice cream is stable for indefinite periods without danger of ice crystal growth; however, above this temperature, ice crystal growth is possible and the rate of crystal growth is dependant upon the temperature of storage. This limits the shelf life of the Ice cream. Ice cream is the only dairy product normally held and sold below the freezing point.

Overrun in Ice Cream

Overrun is usually defined as the volume of Ice cream obtained in excess of the volume of the mix. It is usually expressed as a percentage overrun. This increase volume is composed mainly of the air incorporated during freezing process. The amount of air incorporated depends upon the composition of the mix and the way it is processed; and is regulated so as to give that percentage of overrun or yield which will give the proper body, texture and palatability necessary to a good quality Ice cream. Too much air will produce a snowy, fluffy, unpalatable Ice cream while too little, a soggy, heavy product. Generally, mixes which have high total solids content justify the incorporation of a higher percent air-a higher overrun- than mixes lower in total solids.

The control of overrun is very important and should be as nearly constant as possible from batch to batch and from day to day. The correct overrun percentage depends upon the kind and composition of product and freezing equipment. The desirable percentage overrun in different Ice cream is given in table 15.3:

Table 15.3 Percentage overrun for different ice creams

Product	Overrun (%)
Ice cream, packed	70-80
Ice cream, bulk	90-100
Sherbet	30-40
Ice	25-30
Soft ice cream	30-50
Ice Milk	50-80
Milk shake	10-15

Defects in Ice Cream

Defects in Ice cream may arise due to low quality ingredients, improper mixing, or faulty methods of manufacture and storage. The common defects in Ice cream are:

Flavour Defects

Flavour defects can be classified according to the flavouring system like excess flavour, deficient or unnatural flavour; the sweetening system like too sweet or lacks sweetness; processing related flavour defects such as cooked, dairy ingredient and other defects such as acidic, salty, old ingredient; oxidized/metallic, rancid, or whey flavours, and others storage / absorbed.

Shrinkage

Shrinkage is adequately described as a very troublesome defect in Ice cream since there appears to be no single cause or remedy. After well filled packages are hardened a volume of Ice cream shrinks leaving a space either at the top or side of the package which then appears not full. It is probably due to weak body defect combined with texture defect and becomes apparent with certain temperature changes or type of package. Some factors believed to be associated with the defect are:

- Neutralization of mix or some of the ingredients used.
- Excessive overruns.
- Abnormal ultra low temperatures both when freezing and hardening.
- Fluctuation in storage temperature.

Body and Texture Defects

This defect is due to the presence of ice crystals of such a size that they are noticeable when the Ice cream is eaten. It may be caused by insufficient total solids, improper serum solids and stabilizer or poor stabilizer, improper homogenizing pressure, insufficient aging of the mix, slow freezing because of mechanical condition of freezer, slow hardening and fluctuating temperatures during storage and distribution - the most likely cause.

Melting Quality

Desirable melting quality is shown when the melted Ice cream is very similar in characteristic to that of the original mix. The melting appearance of ice cream is sometimes distinctly foamy. This should be considered a defect and is particularly due to large air cells and large amount of total solids. Emulsifiers or excess gelatin in low solids mixes, as well as a heavy mix consistency, are likely to augment the conditions.

These defects can be classified into three groups:

1. **Curdy Melt-Down:** It is due to visible coagulation of the milk proteins and it is affected by factors which influence the protein stability such as:
 - Excess acidity.
 - Salt balance.
 - High homogenizing pressures.
 - Melting and over freezing in the freezer.

2. **Slow Melting:** It includes not only the Ice cream which retains its shape when warmed but also the various degrees of slow melting to a liquid. It is caused due to:
 - Over emulsification or wrong emulsifier.
 - High fat contents in the mix.
 - Excessive fat clumping in the mix due to homogenization at too low temperature or single-stage homogenizer.
 - Freezing to too low temperatures in a freezer.
3. **Wheying off:** It occurs during the melting of the Ice cream when the mix is of poor quality or if the mix is improperly balanced. This defect can be removed by using high quality dairy products, balancing the constituent of the mix carefully or using a more effective stabilizer.

Colour Defects

Colour and package aid in presenting the tempting appearance essential in a food or dessert. Therefore, good workmanship as evidenced by delicate, appropriate colour, uniformity of colours, not only the uniformity of layers but also the clearness of object outlines in molded Ice creams, the cleanliness and neatness of packages should receive consideration. The ideal colour is characteristic of the flavour, true in shade and neither too pale nor too intense.

The term 'colour unnatural' applies usually to Ice cream in which colour has been used, but may be noticed in vanilla ice cream under some circumstances. An unnatural colour is caused by:

- Carelessness in adding the colour.
- Wrong shade of colour used for flavoured Ice cream.
- Too much yellow coloring used in vanilla Ice cream.
- Grayish colour due to neutralization.

Sensory Evaluation of the Ice Cream

The Ice cream score card (Table 15.4) is a convenient tool or guide to measure the degree of perfection of any given Ice cream. The ideal or standard as indicated by the highest score card serves as the measuring stick to compare or judge the Ice cream. The ideal Ice cream should be packaged in an attractive container, possess a typical, pleasant and desirable flavour, have a close, smooth, uniform body and texture, have desirable melting properties, possess a uniform natural colour and have a low bacterial count. The reliability of the score depends partly upon the judge's conception of the ideal standard and partly upon the ability to recognize very slight defects. The degree of perfection or score may not agree with the acceptability of the Ice cream in a certain market area, although there is usually a rather close agreement.

Table 15.4: Ice Cream Score Card

Particulars	Perfect Score
Flavour	45
Body and Texture	30
Melting Quality	30
Colour and Package	5
Bacteria	15
Total	100

Shelf-Life of Ice Cream

The shelf-life of Ice cream depends entirely on its conditions of storage. It might be one year, or it might be two weeks or less. Although the source of and the contributing factors to the problem of iciness are well known, it is also one of the defects which could be eliminated. The Processors have known it for a long time are often confronted as to how to prevent iciness and the answer is still the same: formulate the Ice cream properly to begin with, freeze the Ice cream quickly in a well-maintained barrel freezer, harden the Ice cream rapidly, and avoid as much as possible temperature fluctuations during storage and distribution.

Soft Ice Cream

Popularly known as Softy is drawn from the freezer without hardening and sold. Softy is short for 'soft-serve frozen desert'. The soft ice cream business in India is a satisfying and financially rewarding business for all levels of the Ice cream business chain.

Soft Ice cream mix is available in powder form or in ready mix liquid form with various flavours. Vanilla, Chocolate and Strawberry flavours are mostly liked by consumers. The powder is blended with water as mentioned by the manufacturer to form a complete mix. This mix is poured into the freezer and drawn in when the consumer demands. The ready liquid mix is also provided by most of the manufacturers directly to the retails in tamper proof packing to maintain the quality and hygiene of the mix. The softy mix is also available in liquid form with UHT processing which the consumers can carry-home and use it to prepare thick shakes or for home made Ice cream.

Kulfi

Kulfi is an indigenous ice cream frozen in small containers. Kulfi is made by boiling milk in a open kadhai with addition of sugar and the product is concentrated to approximately 2:1. To this concentrate, when it has cooled, are added malai (indigenous cream), crushed nuts and a flavour (kesar, rose or vanilla). The mix is placed in triangular, conical or cylindrical moulds of various capacities made of aluminium, stainless steel or plastic cones. The moulds are closed on top by placing a small disc over them and the edges made air-tight with wheat-dough. The mix-in-moulds is frozen

in a large earthen vessel containing a mixture of ice and salt in the ratio of 1: 1 or in a candy tank containing brine solution. In large scale production of kulfi the ice cream mix is condensed to 50 percent concentration in the steam kettle and then cooled to 4°C. Essence of kesar, rose or vanilla and 1 to 2 percent nuts are added and the mix is frozen in the freezer with very low overrun. Kulfi is then packed in moulds or in bulk packs

Dried Ice-Cream Mix

The development of this product has made it easy, for the housewife and the scale Ice-cream manufacturer, to prepare the product for their use at convenience. To prepare Ice cream, one part of the powder is mixed with 1 1/2 to 2 parts of water and the mixture is frozen in the usual manner.

Ingredients: Ingredients are assembled, such as the source of milk fat and solids-not-fat, sugar and stabilizer-emulsifier. Sugar is mainly sucrose although 1 to 25% may be replaced with corn syrup solids or dextrose. Stabilizer-emulsifier combination that have been used are carrageen, carboxymethyl cellulose, gelatin, sodium alginate, and mono- and di-glycerides. Lecithin has both stabilizing and emulsifying properties. A small percentage of sodium caseinate or butter-milk solids may be used to improve the whippability. A small amount of sodium citrate or similar salts is beneficial. The product may be dried with 0 to 10% of the required sugar.

Processing Procedure: The mix or base ingredients with 35 to 40% T.S. are assembled in a vat with sufficient agitation for uniformity. The mix is standardized for percent fat, solid-not-fat, sugar and total solids. The product is preheated to 65 to 70°C for homogenization at 2500 p.s.i, heated to 80 to 85°C for 5 to 10 min. and spray dried or roller dried to a coarse particle with 2.0 to 2.5% moisture, cooled, sifted and packaged. Flavorings such as vanilla are usually added by the user when mix is reconstituted. If desirable, vanilla in the powder form can be dry blended into the base along with a portion of the sugar or a concentrated vanilla added (less preferable) to the Ice cream mix ahead of drying.

Composition of Dried Ice-cream Mix.

Moisture	1.5 – 2.0%
Milk fat	30.0 – 31.0%
Milk solid-not-fat	28.0 – 29.0%
Stabilizer	1.0 – 1.5 %
Sugar	35.0 – 37.0 %

Storage: For storage under severe condition ice cream mix or base should have not more than two percent moisture. The product should be gas packaged and stored in dry place.

Chapter 16

Recombined Dairy Products

Recombination process involves more handling and processing than the simple reconstitution. The major additional equipment required by the processing plants for recombination are: mixing vessels, fat melting equipment and homogenizer.

There are two major types of mixing vessels available for the reconstitution of milk powder and the mixing of additional ingredients. One uses simply a high speed mixing blade, usually with a high shear force which is lowered into the tank of water and turned on as the various ingredients are added. The other system involves the feeding of the dry ingredients through a funnel into a pipeline from the main tank and circulating through a centrifugal pump back into the tank. In this system it is essential to prevent air incorporation during recirculation.

As the fat is added in the liquid form, a homogenizer, preferably two stage, is usually required to emulsify the fat into the reconstituted skim milk.

Some typical recombined dairy products are as under :

1. Recombined fluid milk e.g., plain or flavoured pasteurized milk, filled milk, sterilized milk.
2. Recombined, sweetened condensed milk, evaporated milk.
3. Recombined butter or butter type spreads.
4. Recombined Cheese e.g., cottage, cream, cheddar.
5. Khoa
6. Whipped Cream
7. Cultured Products

Recombined Fluid Milk

The product is easily made and once made is as easily handled and packaged as ordinary fresh milk. The raw materials are usually spray-dried skim milk powder and either cream or butter or good quality milk fat or butteroil. An improved product can be made if about 10% of sweet cream, buttermilk powder is incorporated in the mix. An added refinement, where the law allows, is the addition of a small proportion of a good quality emulsifying agent such as glyceryl monostearate. Full cream powder is not recommended but a proportion can be used if necessity requires. A proportion of fresh milk can similarly be used and, in certain circumstances, can be advantageous. Milk concentrate or evaporated milk, if available in large containers, can also be used.

When making recombined milk, use water at about 47-50°C, and add the powder slowly and steadily, preferably through a mixing of circulating funnel, and continue until the powder has all been dissolved. Switch off the agitator and circulating pump and let it stand for a period of 10-15 minutes. This hydration period is important as it helps to eliminate the powder taste sometimes found in recombined milk. Restart the agitation, add the butter or milk fat, previously melted at about 50-60°C, and then homogenize and pasteurize as usual. It is not necessary to homogenize the complete mixture and both a capital and operational saving can be made by adding all the melted fat to about one quarter of the milk and homogenizing this portion only, adding it to the remainder of the milk at any convenient point in the process thereafter.

While recombined milk can be made to taste the same as ordinary pasteurized milk certain limitations necessarily apply. For one thing recombined milk must always be homogenized.

The butter, if used, must be unsalted and made from nonripened cream; the milk fat or butteroil must be free from any trace of rancidity; the skim milk powder must be of reliable quality and should be of appropriate stability or heat specification – ordinary medium heat powder for pasteurized milk, high heat powder for sterilised milk and heat stable powder for aseptic milk.

The attainment of delicate flavour in recombined market milk requires careful formulation and selection of the ingredients. The quality of the three ingredients, the milk fat, skim milk powder, and water used will determine the flavour characteristic of the recombined market milk. The butter oil must have fine flavour, and the skim milk powder needs to be a low heat type with exceptionally high solubility.

Attempts have been made to produce plain or flavoured recombined sterilized. Both in the process, the in-bottle sterilization and UHT sterilization with aseptic packaging have been successfully used to recombined milk. Recombined milk treated by the UHT process and filled aseptically in to non-returnable container is becoming popular.

Recombined Sweetened Condensed Milk

Provided certain precautions are taken sweetened condensed milk lends itself to manufacture by recombining. The first and most important requirement is that the skim powder used has the right viscosity characteristics and be of high bacterial purity. The second is that the anhydrous milk fat should be of exceptionally high quality. The third is that the quality control and standards of hygiene within the factory must be almost perfect. Sweetened condensed milk, unlike, unsweetened evaporated milk, is not sterilised during manufacture, the sugar in the product being the preserving agent involved. Any carelessness in hygiene will be reflected in the product and the percentage of blown and faulty cans will quickly become unmanageable.

The usual practice in this case is to place about three – quarters of the required amount of water at 47-50°C in jacketed vat. The skim milk powder is added to this either directly or through a mixing funnel, the shearing agitator being set in operation at the same time. The fat, previously melted at about 50°C, is then added and the mixture homogenized (single stage) and pasteurised at 75-80°C and placed in a separate vat.

The sugar is separately dissolved in the remaining water at 90-92°C and is then admixed with the hot milk mixture, still using the shearing agitator to ensure complete mixing. If properly done, the mixture is then ready for seeding and canning. Alternatively, and more simply, especially if a dissolving agitator of the type mentioned is not available, the powder and fat can be dissolved in slight excess of water. In this case the mixture can be drawn into a vacuum pan, the sugar syrup either being re-added to the mixture as above or being drawn directly but concurrently into the pan and being admixed in the vacuum pan itself. Such a mixture could test out at 69-71% total solids and be reduced in the pan to the required 74%. This process has certain advantages and is somewhat easier to control.

Recombined Evaporated Milk

This is an easier product to make than sweetened condensed milk provided the skim milk powder used is of high heat and heat stable. Powder with a Whey-Protein-Nitrogen index of less than 1.5 is of suitable high heat specification but it should be tested additionally before use for heat stability. The milk fat should be of exceptionally high quality with a consistently low peroxide value. Upto 10% of sweet cream buttermilk powder may be added and, of course, any available supplies of good quality local milk may be incorporated, if desired.

Evaporated milk usually contains 9% fat and 22% non-fat solids, making 31% in all. To make this product, take water at 47-50°C, add powder through mixing funnel, add melted fat, heat, homogenize (two-stage 2800/500 lbs. or if buttermilk powder is added, 25000/500 lbs. per sq. inch), and then either cool for storage or heat further to 80-90°C for immediate canning and sterilizing. A hydration period of 10-15 minutes after mixing and before adding the melted fat is recommended.

Problems of recombined evaporated milk are the same as those experienced with the fresh milk product: browning due to too lengthy heating or sterilizing; breaking down or 'cracking' of the protein due to an unstable protein fraction in the powder; and faulty cans due to careless canning or improper sterilisation.

Recombined evaporated milk can be made either by the batch method or continuous method. An evaporation stage using a vacuum pan, is not required unless the quantity of local milk being incorporated is so high as to make the evaporation of part of the water in the milk essential.

Recombined Butter

The commodities required for making recombined butter are anhydrous milk fat, water, and small quantities of skim milk or sweet cream buttermilk powder and, if required, dairy salt. The milk fat must be of exceptionally high quality with very low peroxide value than 0.2.

It is well known, butter made in the usual manner from cream is the result of a phase inversion from fat-in-serum to serum-in-fat. When the butter is further made into anhydrous milkfat, a further inversion does not take place as the serum is completely removed from the fat. When the Anhydrous milk fat is reconverted into butter, serum is again added and a rich cream is produced which once again becomes a fat-in-serum phase. When this phase is again inverted, by passage through the body of a scraped-surface continuous butter maker, butter results and this is the product referred to as recombined butter.

The continuous butter maker barrel is the heart of the operation but if one has to depend on this alone the butter coming therefrom would be too soft and greasy for use. This defect is overcome by passing the butter as it leaves the butter maker barrel through a wide diameter (6" or so) barrel where the fat gets time to crystallise and thus gets rid of its soft, greasy texture. The resultant product when properly made has exactly the same characteristics as ordinary table butter.

Table quality salted butter can be made with 80% milk fat, 2% nonfat milk solids, 1½-2% dairy salt and 16% water. The usual procedure is to place the previously melted milk fat (melting is best done in a warm room at 50°C) in a jacketed vat fitted with a slow moving agitator. The other ingredients are dissolved separately and, when mixed, are added to the melted fat. The cream which results is then pumped through the scraped surface butter maker cooler barrel where it is cooled sufficiently so that after passing through the crystallising tube already mentioned, it is ready for packaging.

The control of the cooling temperature is critical but once adjusted butter will continue to emerge in perfect condition. Plants can be obtained in various sizes but a 1-ton an hour unit will be found to meet the needs of a medium-size packing operation. The use of buttermilk powder instead of skim milk powder is recommended as the buttermilk powder contains nearly 2% lecithin and thus returns it to product from which it first came, i.e., the cream.

Recombined Cheese

Processed cheese is made by blending hard-pressed cheeses, Cheddar or Gouda and melting with an appropriate quantity of water and emulsifying salt in a cheese kettle under conditions of heat and vacuum and then filling the melted cheese into tins, foil packages or other packs. The product usually contains 40-45% water and 50-55% fat in the dry matter. It has a good shelf life even when refrigeration is limited.

The manufacture of Cheddar-type cheese from recombined milk is not too difficult provided appropriate modifications are made to the standard cheese making techniques usually used. Pasteurisation, other than by a brief heating of the recombined milk to 65°C for 5 seconds or so, is not desirable-always assuming the local water supply is safe-as it reduces the clotting ability of the milk. A small quantity of calcium chloride may be added to adjust the salt balance and to aid clotting.

Flavour production in recombined milk cheese can pose problems and care must be taken in choosing suitable starters. It may be necessary at times to include in the starter some non-acid flavour inducing organisms. Mechanically, the manufacture of the cheese can follow the usual lines although depending on the cheese press facilities available, the moulds used need not be standard and can be designed to suit the needs of the processing operation.

Khoa

Attempts have been made to produce recombined khoa using white unsalted butter/ ghee and roller dried skim milk powder.

Whipped Cream

A recombined whipped cream containing 35 percent butter oil, 0.5 percent glycerol monostearate, 8 percent cream serum powder and 56.5 percent water has been developed in Australia. Similarly, a low fat recombined whipped cream containing 18 percent butter oil, 0.75 percent emulsifier, 0.25 percent stabilizer, and 70 percent water has been developed in USA.

Cultured Products

Fermented milks such as yoghurt, cultured buttermilk, and sour cream have been successfully prepared by using recombined milk.

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Chapter 17

UHT Processing and Aseptic Packaging of Milk in pouches

UHT or long-life milk in aseptic packages in an answer to consumers' needs. What it ensures, apart from wholesomeness, is good raw milk quality, hygienic processing, convenience and long shelf-life of milk at ambient room temperatures. It avoids the cold chain during distribution, storage and at the point of sale reducing the logistic costs. The flexible pouch offers tremendous cost saving in the packing material. The pouch is easy to recycle, thus is eco-friendly.

UHT milk packaging in India has grown from 100 million litres in 2004 to 600 million litres in 2010. Taste, convenience and distribution will no doubt contribute to the fast growth of UHT milk. As more people become aware of this technology and its benefits and know where to find the product, UHT milk will grow further.

Pasteurization of milk has several limitations in terms of chilled distribution, shorter shelf life and extent of distribution. Of the approximately 25% of total milk processed in India today, more than 98 percent is in the pasteurized segment and less than 1 percent in Ultra-High Temperature (UHT).

It is likely that for an existing dairy, the UHT milk segment is just an extension of the pasteurized milk processing. Since the entire infrastructure for the dairy plant exists, the UHT equipment would be simply an extension. One needs to add a sterilizer and aseptic filling machine – as per requirement and upgrade the existing facility's utility section.

To achieve the longer shelf life, the product is treated at UHT, i.e., it is heated at 140°C for a brief period and then rapidly cooled to room temperature. In Aseptic Pouch packing technology, the film and the product filling path are sterilized using hydrogen peroxide, in a very innovative way, to sterilize the co-extruded, multi layered packaging film with EVOH barrier. The triple sterilization principle employed in the design of the machine ensures that film is thoroughly washed and sterilized before it reaches the filling point. The filling is done in sterile atmosphere to avoid re-contamination, thus aseptically packing the product.

The aseptic processing system vis-à-vis treatment with UHT is applied to market milk, flavoured milk and many other products. The UHT processing system involves indirect steam injection type UHT Sterilizer with straight tube in tube type tubular heat exchanger

to sterilize the products at capacity ranging from minimum 2500 L/hr to maximum of 6300 L/hr including 5% recycling. The Aseptic Pouch Packaging System is integral and synchronized with the Sterilizer having a capacity to pack max. 10800 Packs/hr. The filling machine is double head type allowing the possibility of packing two different pack sizes at a time with each head having a capacity to pack 3600 packs/hr. The Machine is able to fill varying pack sizes from 180 ml to 1000 ml.

Complete Unit of UHT Plant

A complete UHT assembly consists of

- Sterilizer
- Homogenizer
- Aseptic Packaging Machine
- CIP System

The advantages of UHT assembly are:

No cold chain is needed. The products can be kept in the normal room temperature.

Low – cost LDPE – based packaging foils can also be used.

The modern automation saves labour costs and minimizes production losses.

The compact construction and flexibility mean economy even in small – volume plants.

The UHT system can process and pack :

- Milk
- Flavoured Milk Drinks
- Yoghurt-based Drinks
- Fruit Juices
- Soft Ice Mix
- Milk Shakes Mix
- Nutrient Solutions

Principle of Operation :

The plant is fully automated for production steps ascertaining the sterility of the product, CIP Steps, homogenization of the product, etc. The system should start with circulation of hot water with a pressure for the prescribed time and temperature. Immediately after pre-sterilisation the system is aseptically cooled down step by step to the production temperature. The system is incorporated with different straight tube bundles viz., regeneration, heating, cooling, holding, etc. The plant is having the facility to perform automated CIP after and in between production. The Flow Diagram for Aseptic Filling is given in Figure No. 17.1.

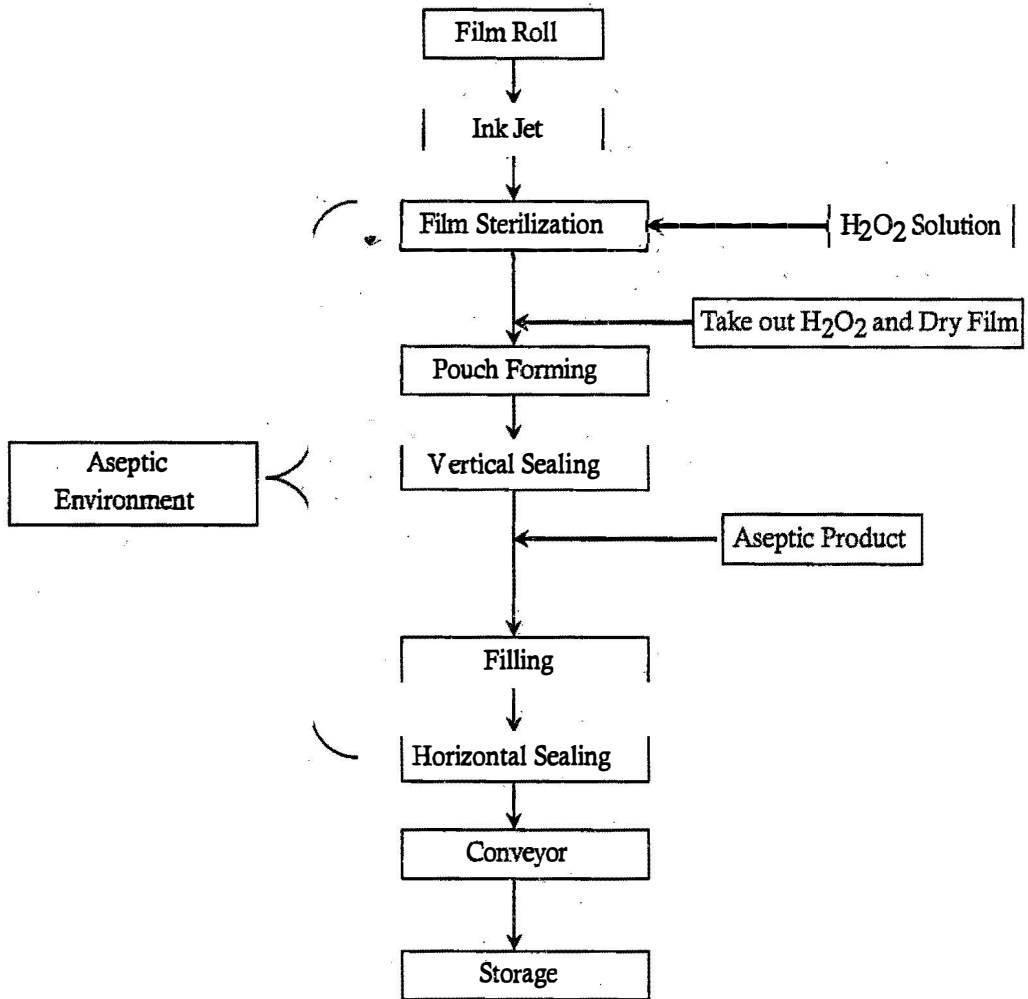


Fig. 17.1: Flow Diagram for Aseptic Filling

1. UHT Sterilizer

The sterilizer consists of required amount of straight-type heat exchanger cartridge, the amount of cartridge being determined by the desired sterilizing capacity. Its control is automatically synchronised with the filling machine. The Picture of Automatic UHT Plant is given in Figure No. 17.2.

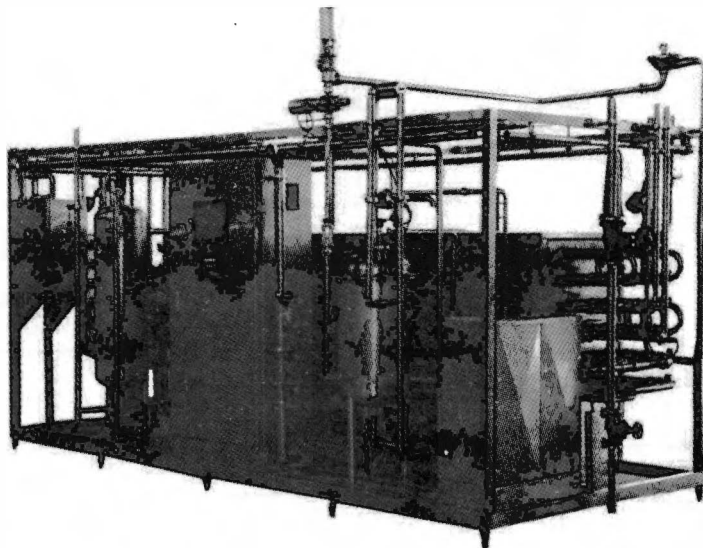


Fig. 17.2: Automatic UHT Plant

The control and alarm system is equipped with temperature recorder and temperature control unit and with automatic recycle valve in case the sterilizing temperature decreases below the set temperature.

The daily sterilizing of equipment is performed by circulating water through the piping. During the circulation the temperature of the water is raised up to + 140°C and after which the plant will be taken for production.

Balancing Equipment

The balancing equipment functions as a balancing unit between the sterilizer and the packaging machine. This should replace aseptic intermediate tanks. In case one of the filling head is momentarily stopped the sterilizer capacity can be adjusted to suit the remaining packaging capacity. The quantity of the recycled product is approx 5%.

Balancing equipment should consist of aseptic product valve, changeover valve and pressure regulating valve connected to the product line for sterilized milk and to the return product line.

Sterilization

The process of Sterilization is described below:

The product is pumped into the balancing tank at the temperature of 5 – 10°C. From the balance tank the product is pumped to the first heat exchanger where it is heated up to 70°C and then directed to the homogenizer.

The non-aseptic homogenizer regulates the rate of flow and pumps the product further to the second heat exchanger. In the second heat exchanger the product temperature is raised to 90°C and then cycled through special protein stabilization tube during 70 seconds.

After the protein stabilization the product re-enters the third heat exchanger to obtain the final sterilizing temperature of 140°C.

After that the liquid product flows into the holding tube where the product is held at the temperature of 140°C for about 3 seconds in order to achieve the sterilizing effect. After the holding tube the product flows through the fourth heat exchanger emitting heat into the incoming water.

The temperature has now dropped to approx 21 - 26°C. In the fifth heat exchanger the product temperature is dropped to normal packaging temperature of $20 \pm 5^\circ\text{C}$ by using tap water or ice water for cooling. The need of cooling depends on the product inlet temperature. After the cooling the product flows to the aseptic packaging machine.

Cleaning

The cleaning of the sterilizer and the whole plant is carried out automatically with CIP equipment by preset programs for intermediate and final cleaning.

2. Homogenizer

Functional Description

Sanitary design for cleaning in place (CIP).

The homogenizer is equipped with remote-controlled speed adjustment, which is situated in the central control panel of the sterilizer. All its parts in contact with the liquid are of stainless steel. The machine is enclosed in a cabinet of polished stainless steel and equipped with forced lubrication system.

The homogenizer is equipped with the following indicators:

- Milk input temperature

- Input pressure

- Output pressure

- Homogenizing pressure

3. Aseptic Packaging Machine

Functional Description

Pouch filling machine is a fully automatic packaging machine (Fig No. 17.3) for liquid products producing pouch packages aseptically and automatically.

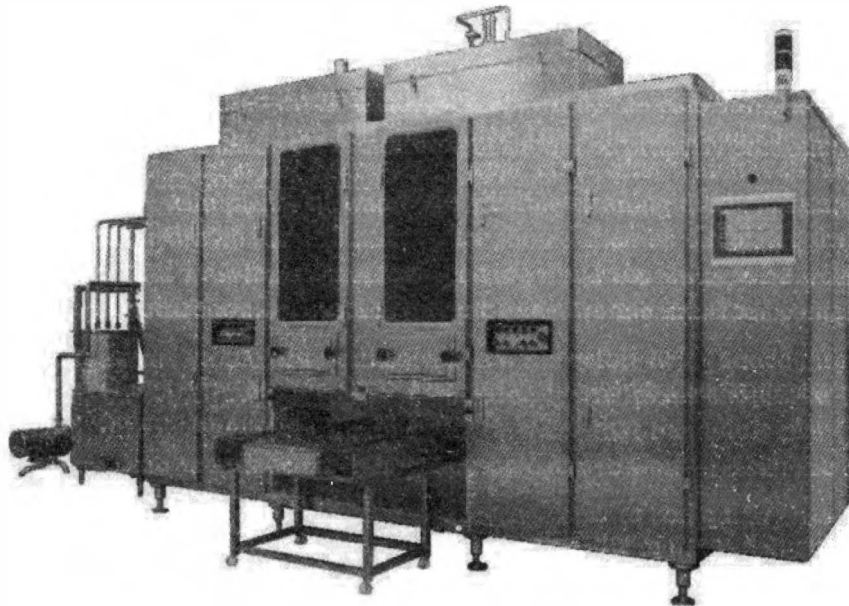


Fig. 17.3: Automatic Plastic Pouch Filling Machine

The aseptic condition is achieved by sterilizing the film with Ultra Violet (UV)-radiation and heated/immersed in hydrogen peroxide bath and by holding continuous positive sterile air pressure inside the film and UV cabinet.

The film should travel from the roll through the slackener and hydrogen peroxide bath to the UV cabinet. In the sterilizing cabinet both sides of the film are treated with effective UV-radiation. After sterilizing, the film is folded by means of a triangular turning device so that the surfaces to be sealed are pressed against each other. The film indexing can take place using Servomotor-controlled pulleys.

The metering and sealing should take place in the fill and form cabinet.

The sterile air is generated using a separate sterile air generating system and directed into the filling and sealing cabinets of the machine generating positive pressure inside and keeping the machine sterile and maintaining the aseptic condition.

The metering device parts remaining in the pouch blank are sterilized before starting the run. The interior sterilizing of the metering device is carried out before starting the packaging with super-heated water (+ 120°C).

Both, the horizontal and vertical sealing devices are of continuously heated type. Steplessly adjustable temperature control is equipped with sealing temperature indication.

The metering device is a piston/cylinder metering pump functioning with the pressure of the product to be portioned. The liquid flow is in a hermetically closed system constructed especially to meet the requirements of sterile packaging.

In order to keep the air of packaging room fresh the machine is equipped with an exhaust air outlet with duct connector for removal of any possible fumes generated during film sterilizing process.

The Accessories of Packing Machine:

Coding Unit

A hot foil-stamping device stamps min. 9+9 digits on the film to indicate the packaging date, the last selling date or other information.

Pouch Counter

An indicator of the machine is provided in the drive panel which countermeasures the number of portions.

The blower sucks in the dry ambient air via the intake line, through the Air Pre-Filters. The intake air is then “Compressed” (about 0,1 bar overpressure) and led through the Sterile Air Filters and forwarded into the packing machine(s). The sterile air filters retain micro organisms and all kind of bacteria and/or other contaminants.

The Sterile Air Filters are sterilized before starting a production run by means of filtered steam (4 bar or + 140°C) led in the unit via the Steam Line. During sterilization process the airline downstream of the blower is automatically closed to protect the blower from the steam. After sterilization of the Sterile Air Filter the condensation is drained out from the condense valves.

Specifications For Packaging Material

The packaging material should be high quality pre-sterilised, flexible packaging material processed from virgin LLDPE/LDPE; suitable for forming, filling and sealing in Aseptic Packing Machine. It should have following specifications :

- Amount of Film Layer 3 or 5
- Thickness 100-120 micron.
- Width 260-320 mm
- Structure grey/black/white, black / white
- Raw Material LLDPE, LDPE
- Printing 1-6 Colours

Recommendations For The Packaging Film

LDPE / LLDPE film is an economical solution for short shelf life (10 – 30 days).

PA / LDPE + LLDPE film for medium –length shelf life (1 – 3 months).

PETP / A1 / PA / LDPE + LLDPE for long shelf life (3 - 12 months).

The barrier layer can also be of EVOH or PVDC.

4. CIP System

The CIP equipment is designed for automatic circulation and washing of filling machines and sterilizer. There is washing programs for intermediate and final washing in the equipment.

Only the CIP of the sterilizer is carried out intermediately after the heat exchangers have become impure by operating for a long time. After the intermediate washing the processing can be continued normally. The intermediate washing may take approx. 20 minutes.

The final washing is performed both for the sterilizer and the filling machines after the processing has ended. The final washing takes approx. 55 ~ 60 minutes.

The washing programs and washing times is as follows:

	Intermediate Wash	Final Wash
Rinsing (Cold Water)	3 min	4 min
lye Wash (1.5~2%)	4 min	16 min
Intermediate Rinsing (hot water)	4 min	10 min
Acid wash (2 ~ 3%)	4 min	14 min
Final Rinsing (hot water)	5 min	14 min
	20 min	58 min

Chapter 18

Emerging New Technologies in the Dairy Industry

India is currently the largest producer of milk in the world, a status it has maintained since the late nineties. Further, India is also self-sufficient in milk.

The dairy industry in India has gone through major changes with the greater participation of the private sector. This is also consistent with global trends, which could hopefully lead to greater integration of Indian dairying with the world market for milk and milk products. India today is the world's largest and fastest growing market for milk and milk products with an annual growth rate of about 4.5 percent.

The value addition and variety in the availability of milk products are on everybody's agenda. There is an increasing demand for new products and processes. The main reasons are - an increase in disposable incomes; changes in consumer concerns and perceptions on nutritional quality and safety; arrival of foreign brands; increasing popularity of satellite/cable media; and availability of new technologies and functional ingredients.

India's milk production as projected for the period between 2004 and 2010 is given in Table No – 18.1.

Table 18.1 : Projected Population and Milk Production, 2004-2010

Year (fiscal year ending March of the year shown)	Projected Population (million)	Annual Milk Production (million tons)	Per Capita Availability Projected	
			Kg/year	Gram/day
2004	1 065.8	91.9	85.38	233.91
2006	1,100.0	99.0	90.0	246.57
2008	1,134.3	107.0	94.33	258.43
2010	1,168.1	115.00	96.31	263.86

New Products and Processing:

Since time immemorial traditional Indian milk products have been an inseparable part of the socio-cultural life of India. Be it childbirth, wedding ceremony, getting a job, inauguration of a new house, feasts, festivals, social or religious occasions milk sweets are always offered. The mass appeal enjoyed by the indigenous sweets is underlined by the fact that about 50% of India's milk production is utilized for making these products.

The market for these products far exceeds that of Western milk products like butter, cheese and milk powders. The total output of Indigenous milk products is estimated to be 12 billion USD. This is more than half of the total market (22 billion USD) of milk and milk products in India. The traditional dairy products present a great opportunity for the organized dairy sector in the country to modernize and scale up their production. Their production and marketing can bring about remarkable value addition to the extent of 200%, as compared to only 50% obtained by Western products. The consumption of traditional dairy products is likely to grow at an annual growth rate of more than 20%, but for Western dairy products the growth rates are relatively much lower, varying from 5-10%. Thus, the expanding business prospect provided by the traditional Indian dairy products to the organized dairy sector triggers a thorough face-lift of these products.

Khoa and Khoa based Sweets: With the successful innovation of Scraped Surface Heat Exchangers these products can be easily adopted by the Indian dairy industry. Some of the dairy products manufacturers are already using this machine for manufacturing of burfi, peda and gulabjamun. About 15 plants in India have initiated industrial production of khoa with daily output of 1 to 4 ton using continuous khoa making machine. There are large number of khoa based sweets. These sweets are also gaining wide acceptance in South Asian and African countries, UK, Canada and the USA. Technologies have been developed for industrial production of sweets from khoa, non-fat dried milk, cream or butter, whole milk powder or full cream concentrated milk. The manufacturing operation in the production of burfi, commanding major market share, involves heating the mixture of the above ingredients in a scraped surface heat exchanger, cooling on a continuous conveyor belt, cutting to size and packaging.

Paneer Chhana and Chhana Based Sweets : Products made from traditional method have limited shelf-life not exceeding a few days. The entire traditional technology can be improved and modernized by employing mechanical systems such as casein process for chhana and paneer making.

The growth projections for their demand in the organized sector are presented in Table No – 18.2 This is the demand that is met by the milk processing plants organised on larger scale and they are other than the traditional small players, like halwais etc.

Table 18.2: Demand for Major Milk Products in the Organised Sector, 1988-2009 / (MT)

Product	Demand 1988	Demand 2009
Ghee	100,000	200,000
Cheese	4,200	15,000
Paneer	1,000	16,000
Shrikhand	3,000	5,650
Rasogolla	1,600	6,000
Gulabjamun	3,000	5,850

Extended Shelf Life of Pasteurised Milk: In order to cope up with the increasing demand, it becomes necessary to produce pasteurized milk with extended shelf-life to extend the market reach at reasonable cost of production and distribution. Production of pasteurised milk with extended shelf-life would be economically beneficial both to producers and consumers. Shelf-life of pasteurized milk could be extended by adoption of higher pasteurization conditions, LP- system, bactofugation technique, micro-filtration technique, electrical process, thermization process or use of bio-preservatives.

New Whey Products: In India, whey is obtained during the manufacture of paneer, chhana, casein and shrikhand. It has been estimated that about one million ton of whey is annually derived as a by-product which possesses about 70,000 tonnes of nutritious solids. Whey is obtained in our country as by-product is mostly thrown away as waste. No proper attempts have so far been made particularly on a small scale to exploit this by-product. Considerable economic benefit can also be secured from prompt utilization of the whey.

Whey can be converted into a range of products viz., whey powder, lactose, high protein whey powders, whey protein concentrate, granulated high protein whey powders. These products can be used in infant foods, weaning foods, bakery products, confectionery products, dairy products, etc. Beverages and soups are generally consumed by large number of people for the reasons of their being refreshing, tasty and nutritious.

UHT Processing and Aseptic Packaging:

Considered as the single most important innovation for Dairy products in the last half-century, it involves producing shelf-stable products by sterilizing the product and the packaging material or container separately and filling in a sterile environment. It was popularized in India with the success of fruit juices, drinks & milk such as Amul Taaza.

Super Heated Water Spray Sterilizer

Early methods for sterilizing milk involved filling milk into heat resistant glass bottles, then sealing them with air tight, pressure resistant caps and heating in a commercial pressure cooker (or retort) to temperatures between 115^o C and 122.7^o C for between 12 and 20 minutes. The retort process can include an agitation step which helps reduce heat transfer time and combats settling and separation.

A new method of sterilization has been developed called “Super Heated Water Spray Sterilizer” for heat sensitive products. This is suitable for delicate containers like plastic bottles. This system is suitable for rapid heating and rapid cooling for heat labile products. Fig. No – 18.1 shows Picture of Super Heated Water Spray Steriliser

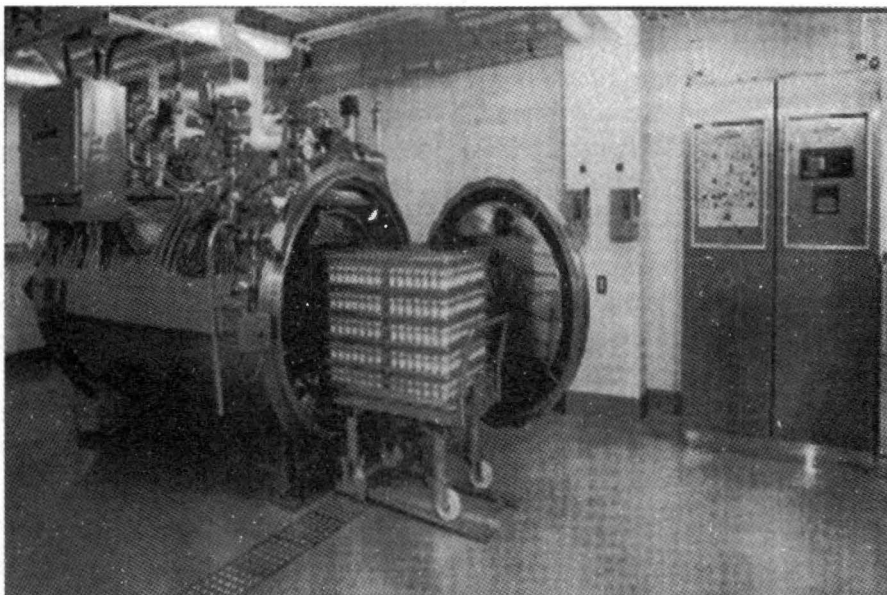


Fig. 18.1: Super Heated Water Spray Steriliser

Membrane Processing:

Recently, membrane processing has gained importance over conventional processes in Dairy industry for its advantages that are well known and established. Membrane processing has presented new possibilities for the production of newer intermediate dairy products that can be used in different foods based on their functional properties.

Membrane technology techniques include (a) reverse osmosis for concentration, to complement or replace evaporation, (b) nano- filtration for desalting and deacidification, concentration and purification, (c) microfiltration for clarification instead of centrifuges and sterilization instead of heat, (d) ultra filtration for fractionation, concentration and purification, (e) electrodialysis for demineralization instead of ion-exchange and (f) pre-evaporation instead of extraction and / or distillation. These applications, which are already commercial, are being used in dairy industry, fruit juice industry, sugar refining, corn refining and soyabean processing.

Modified Atmosphere Packaging

Antimicrobial agents such as carbon dioxide have been shown to extend the shelf life of milk through a process called modified atmosphere packaging (MAP). Carbon dioxide gas (CO_2) is a natural antimicrobial agent, and has been shown to inhibit or slow bacterial growth, in turn, extending milk's shelf life. In addition to carbon dioxide, MAP solutions may entail the combination of other gases, such as nitrogen, or argon – but these gases have not yet been approved for use in fluid milk processing. Successful

implementation of MAP depends on many critical factors, including the actual gas mix, headspace-to-product volume ratio, permeability of barrier materials used, water activity, temperature, process controls, etc. Commercial success has been found when headspace in certain food packages is purposely replaced with specific gas and gas mixtures to extend shelf life, increase convenience and reduce the need for additives and preservatives.

High Pressure Technology

High-pressure technology is a very promising non-thermal food preservation method. The technology of high pressure processing (HPP), also referred to as ultra high pressure (UHP) or high hydrostatic pressure (HHP) has been known to be a potential preservation technique for more than a century for instance, microbial spoilage of milk could be delayed by high pressure. Technical-scientific progress has led to a renaissance of food pasteurization by hydrostatic high pressure recently. A range of pressure-treated products has already been introduced into the markets of Japan, France, Spain and USA. HPP subjects liquid and solid foods, with or without packaging, to pressures between 100 and 800 MPa. Exposure times can range from a few seconds to over 20 min. Food treated in this way has been shown to keep its original freshness, colour, flavour and taste.

Using high pressure can quickly pasteurise, or in some case sterilise, food products with little or no heat treatment. This results in products that have a good natural taste and texture, while retaining those nutritional factors that would otherwise be degraded by heat e.g., vitamins. The aim here is to replace either pasteurization or micro filtration with high pressure. It has been found that milk pasteurized by high pressure can be kept at refrigeration temperatures for several weeks. Pressurization at 7,000 atmospheres for 10 minutes at 20°C can reduce to normal flora of milk on acceptable levels.

Pulsed Electric Field Processing:

Pulsed electric field (PEF) processing uses strong pulsed electric currents to deactivate microbial cells, effectively preserving foods with little or no actual heat. For food quality attributes, PEF technology may be superior to traditional heat treatment of foods because it avoids or greatly reduces the detrimental changes to the sensory and physical properties of foods. PEF processing involves the application of pulses of high voltage (typically 20 – 80 kV / cm) to foods flowing between electrodes. It may be conducted at ambient, sub-ambient, or slightly above ambient temperatures for microseconds, minimizing heat generation due to energy transfer. Only pumpable food products can be treated.

Ohmic Heating

Ohmic heating (OH) is based on the passage of alternating electrical current through a biological fluid that serves as an electrical resistance. The electrical current is passed along or across a flowing fluid, and the electrical power introduced into the product is

translated into heat which results in rapid and uniform heating. Ohmic heating is also called electrical resistance heating or electro-heating, and may be used for a variety of applications in dairy and food industry. The process passes an electrical current directly through pasteurized milk, which is flash-heated to destroy virtually all bacteria. Protein denaturation, one measure of the chemical and flavour changes caused by heat exposure, is about 67 percent in the commercial UHT sample and dramatically lower in the electroheated sample at only 30 percent. Packaged aseptically, electroheated milk can maintain its quality for upto one year.

The electroheating technology has been developed for applications that were not feasible by heat exchangers. This method rapidly kills microorganisms and viruses, while the taste, aroma and nutritional value of the product remains unaffected. OH is a novel technology for heating fluids in the food for the purpose of sterilization and pasteurization, providing fast heating rates, more uniform heating and improved product safety and quality. The OH system enables extremely rapid heating, and relatively rapid cooling that enables destruction of microorganisms and viruses before damaging the biochemical functionality of the product.

Spinning Cone Column Technology (SCC) for Flavour Management

The Australian company Flavourtech has applied its unique Spinning Cone Column Technology (SCC) to the capture of flavours from food products. Flavourtech's Spinning Cone Column is the world's fastest, most efficient and cost-effective method for the capture and preservation of volatile flavour components, from all kinds of liquid or slurry substances. This unit handles a wide range of products, such as Dairy products like milk, cream, hot beverages like tea, coffee, malt drinks; Fruit & Vegetable juices; products like juice oil, Alcoholic beverages, etc.

By processing raw milk through an SCC system upon delivery to the dairy, the undesirable aromas can be selectively removed restoring milk's fresh, delicate aroma. The SCC is now the industry-preferred method for cream deodorization in New Zealand. The patented design of the SCC is unlike traditional systems and allows deodorization to take place faster, at lower temperature and without damage to the stripped product.

Automation in Dairy Plants

Most of the dairies, in India, have been traditionally with low volume, fixed production lines and very little or no automation. The percentage of automated dairies is hardly 10 percent of the total installed processing capacity, which has to be improved. Automation is a method of making repetitive and routine functions in a process with minimal human intervention focusing on achieving consistent quality product at desired throughput and optimum cost. It has many advantages for the dairy industry such as Handling Large Quantities, Online Operational Flexibility, Consistency in Product Quality, Efficient Management of Plant, Minimal Product Losses, Energy Conservation,

Inventory Control etc. Today, the automated system is completely integrated compatible with ERP and MIS data generation. The key features are end-to-end automation from milk reception to milk dispatch, Automatic on line Fat / SNF standardization, Automatic CIP cleaning with minimum chemical consumption and water.

The main thrust of the market development effort should be towards improving and standardizing the quality to meet consumer expectations. With liberalization of world economies, there is greater market access for hygienically produced and packaged foods from outside India. The consumers are now better informed and have greater expectations. Quick and sincere efforts are required to bring automation into the manufacturing process because current practices make health conscious consumers skeptical about the quality. Improvements in the hygiene levels will also help meet the sanitary and phyto-sanitary requirements under the World Trade Organisation regimen, which are essential for export.

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Chapter 19

Packaging of Milk and Dairy Products

Packaging is a technique of using the most appropriate containers and components to protect, carry, identify and merchandise any product. It constitutes an important link between the manufacturer and ultimate consumer for the safe delivery of the product through different stages of production, storage, transport, distribution and marketing.

Though great efforts have been made in producing high grade processed milks or manufactured dairy products, unless they are delivered in a fresh, sound and suitable form to the consumer, they are likely to be rejected, thus causing enormous wastage. The loss can be offset to a great extent by adequate protective packaging to withstand the hazards of climatic changes, transportation, handling etc.

Because of rapid growth in the economy and consequent improvement in the living standards of the common people, packaging has become important in the distribution process. In today's busy world, many consumers do not have the time to make it to the market. Internet is used to purchase groceries.

Innovative packaging technologies have become a necessity for the development of extended shelf life and value added foods and food products. In food industry, the package serves as a barrier to contamination by microorganisms or other undesirable elements like moisture and light.

The packaging material should satisfy the following conditions:

It must protect and preserve the commodity from the time it is packaged till the product is consumed; It must be suitable for the selected sales and distribution pattern; It must

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Packaging Materials

Popular materials used for packaging different milk and dairy products are paper carton boards, paper, coated paper, coated paper wax, plastics, aluminum foil, glass, tinplate, and laminates.

Cartons are the cheapest amongst all the packaging materials. They are printable for labeling purpose, environment-friendly and have a poor moisture barrier property. To overcome these deficiencies, cartons with plastic inner and outer liners or PE-lined papers have been developed and are widely used. The papers are used commonly in the form of wrappers, cartons, boxes, bags, etc. A wide variety of rigid plastics can be used as thermoformed, such as bottles. Flexible plastic packaging films are used as wrappers/bags/pouches. These are of two types namely low polymers which includes cellophane (coated with polyethylene) and high polymers which includes polypropylene, polystyrene polyester, etc.

Aluminum foil has good barrier properties, is greaseproof, shrink-proof, odourless and tasteless, hygienic, non-toxic, bright in appearance, etc. The common thickness of this medium for use in products is 0.012 to 0.15 mm. Glass may be transparent or opaque. It is used in the form of bottles, jars, jugs, etc. Rigid plastic bottles are in use for packaging milk and liquid milk products. Glass has the merits of strength, rigidity, and an excellent

gas and water vapour barrier while the disadvantage is of heavy weight and fragility. Tinplate consists of a thin sheet (0.025 mm thick) of mild steel coated on both sides with a layer of pure tin. Tinplates have the merits of good strength, excellent barrier properties while the demerits are of high cost, heavy weight, difficult reclosure and disposal.

Laminates are made to further strengthen the film material to improve properties, improve grease-resistance, and provide a surface that will heat-seal, etc. Some typical laminates are paper polythene, cellophane-polythene, and polyester-polythene.

Pouches

Today, even in smaller cities, milk pouches have become popular due to the convenience they offer. A good consumer response to milk pouches paved the way for the technological changes needed in the industry. Initially, the form-fill-and-seal (FFS) machines used for packaging of milk in pouches were imported but these machines are now manufactured indigenously by a number of units in the country. Availability of plastic films needed for the pouches also increased during this period, with a large number of entrepreneurs taking up the production of multi-layer films for milk packaging.

Cartons

The cartons are the preferred medium for packaging milk. They are also used for packaging liquid, frozen and coagulated milk products. Cartons are commonly made of food grade paper coated inside with wax or plastics; or lined with paper, plastic films or aluminium foil; or made of laminates. The merits include maximum space utilization in vehicles, and storage; ability to carry attractive printing and convenience as a means for stacking milk at super market shelves.

Retailers in the developed countries consider it the best available package for self-service selling. Cartons also play a role in the bulk packaging of milk. Cartons are commonly available either as preformed containers or as pre cut blanks ready to be formed in to containers.

Bulk Vending through FRP Tanks

This system was introduced by Mother Dairies operated by the NDDB in metropolitan cities. It was mainly to facilitate milk distribution over a wide area by transporting milk in road tankers at the delivery points. The system had Fibre Reinforced Plastic [FRP] tanks fitted with automatic dispensing device. As a result, it was possible to offer milk at a much economical rate to the vulnerable sections of the society. Hundreds of such FRP tanks are operational in the retailers' premises and they became very popular.

Modified / Controlled Atmosphere Packaging

Modified Atmosphere Packaging means enclosing a food product in an atmosphere inside gas barrier material, in which the gaseous environment has been modified to

slow down respiration rate, microbial growth and reduce enzyme degradation all with the intention of extending the shelf-life of food product. Such modification generally results in the reduction of headspace oxygen and increase in CO₂ and N₂ levels. In addition, films used in Modified Atmosphere Packaging also have optimum transmission to water-vapour so as to minimize changes in the moisture content inside the package.

Biodegradable/Edible Packaging Materials

Edible polymer films are a thin layer of edible materials formed on a food as a coating or preformed on or between food ingredients. Its purpose is to minimize the transmission of oxygen, aroma and fats and oils.

Biodegradable polymer films are degraded completely by microorganisms in a composting process to natural compounds such as CO₂, H₂O, methane and biomass. In the use of biodegradable films, factors such as package storage conditions, susceptibility to insect infestation and microbial food safety problems should be considered.

Packaging of Products

1. Shrikhand

With the increased availability of milk, need for marketing milk related products have also grown. Though many of these products have been traditionally made in most of the Indian homes, their commercial availability became a reality due to emergence of better packaging techniques. The Baroda Dairy has installed a machine in which High Impact Polystyrene (HIPS) sheets are heated and formed into cups or trays and then filled with shrikhand which is heat-treated in order to extend its shelf life prior to filling. Sealing of the cup or tray with polystyrene film or aluminium foil coated with paper and wax follows immediately to give a continuous flow of nicely packed and sealed cups of shrikhand. The entire process of forming, filling and sealing is done as a single continuous operation, thus minimizing the risk of contamination.

Plastic cups are moisture-proof, leak-proof and convenient to use. Weight of the HIPS varies from 5 gms to 35 gms and thickness between 0.3 mm and 0.65 mm. These cups have capacities from 100 ml to one litre.

Flexible packaging materials like vegetable parchment paper or grease proof (GP) paper, aluminium foil, and folding board cartons which together give protection, are more commonly used.

3. Ghee

Multilayer co-extruded films of LDPE/HDPE are being increasingly used for short term storage. Generally, plastic pouches are filled on automatic FFS machines.

4. Cheese

The packaging used for cheese should prevent escape of moisture and disallow oxygen so as to prevent oxidation of fat and mould growth. Tinplate cans are used for 200 gms and above quantity. PVDC coated plastic films are suitable for cheese packaging as they provide good oxygen and moisture barrier properties.

5. Condensed and Evaporated Milk

Since these products are expected to remain wholesome for a year or even longer, such types of milk are normally packaged in metal containers – e.g., cans or barrels. Cans are usually of tinned mild steel lined with a special lacquer; aluminum cans may also be used.

6. Dried Milk Powders

Since whole milk and infant milk powders are rich in fat (20-30 percent), packaging material should provide protection against oxygen and moisture. Generally, tinplate cans are used, and packaging is done to replace air by nitrogen in the headspace of the tin cans. Skim milk powders have very low fat content and as such a good moisture barrier material is adequate for short term storage. Multiwall paper sacks with one polyethylene liner is used for bulk packaging. Lined cartons are used for retail packaging. Some skim milk powder is also sold in polyethylene bags of 1 kg. Even plastic bottles of HDPE are being tried for 200 gm and 400 gm of powder.

7. Ice Cream

Since Ice cream is stored at very low temperatures, packaging material used for ice-cream should have low temperature stability. It should also provide protection against contamination. High impact polystyrene (HIPS) cups are also becoming popular.

8. Indigenous Milk Products

Pedas are first wrapped in grease proof paper and then placed in cartons lined with GP paper. Products like lassi in 200 ml plastic pouches packed on FFS machine is a recent introduction in the Indian market. Sweet curd is packed in HIPS cups, while local vendors use LDPE bags for loose sale of fresh curd.

Standardization in Packaging Materials

The Bureau of Indian Standards is already engaged in the development of standards for packaging materials. With rapid industrialization and the improvement in the transportation methods, packaging standards would have to be reviewed periodically so as to effect an economy in packaging which is so vital to improving productivity as well as national and international trade.

The use of so many different packaging materials makes it important to examine the

nature and properties of the constituent elements of these materials used to package foodstuffs.

Second in importance to the physical and mechanical characteristics, which make a type of packaging suitable for a specific purpose, are its toxological properties. These properties determine the conditions of use for materials in contact with foodstuffs intended for human consumption.

Chapter 20

Use of Membrane Processing in the Dairy Industry

Membrane separation process is a pressure driven separation process which has several applications in food and dairy industry. Membrane separations are based on the ability of the semi permeable membrane of the appropriate physical and chemical nature to discriminate between molecules primarily on the basis of sizes. A membrane's role is to act as a selective barrier similar to osmosis. Conventional filtration process is used for separation of suspended particles $> 10\mu\text{m}$. Membrane filtration separates substances of molecular sizes $< 10\mu\text{m}$.

Membranes

Membrane is the heart of membrane process. Wide varieties of membranes are commercially available. Membrane occurs in living cell with function of active transport with semi-permeable properties. A synthetic membrane is an inter-phase, which separates two mediums and restricts transport of various chemical species. A membrane can be homogeneous or heterogeneous, symmetric or asymmetric in its structure and it may be either neutral or may carry positive or negative charges or both. Mass transfer through a membrane may be caused by diffusion of individual molecules or by convection flow induced by an electric field or a concentration pressure or temperature gradient.

The most important structural properties of a membrane are: i) Chemical nature ii) Microcrystalline structure iii) Pore statistics (pore size, pore-size distribution and density and void volume) iv) Degree of asymmetry. The important functional properties of membrane are (a) Permeability and (b) selectivity.

Membrane shall have following secondary properties: The secondary properties of the membrane should be its resistance to compaction, temperature and chemical, microbial attack. Additional requirements are: good tolerance to cleaning and disinfection chemicals, non-toxicity of materials.

Separation in membrane processes are the result of differences in the transport rates of chemicals passing through the membrane interphase. The transport rate is determined by the driving force or forces acting on the individual components and their mobility and concentration of solute within the inter- phase determined how long a flux is produced by a given driving force. The mobility is primarily determined by the solute's molecular size and the physical structure of the inter-phase material (hardness, crystallinity, polymer chain, flexibility, etc.).

Advantages of membrane systems: 1) The removal of water is accomplished without a change in its state 2) Membrane process can be operated at ambient temperature. 3) Very low energy requirement compared to evaporation, drying, freeze drying. 4) No thermal degradation of nutrients and, 5) Better nutritional and functional properties of milk constituents.

Limitations of Membrane Systems: Membrane have the limitation : 1) limitations of total solids (<50%), no drying. 2) High viscosity of the concentrate limits the process. 3) Fouling of membranes. 4) Poor cleanability 5) Reaction with cleaning agent.

Types of Membrane in Filtration

Cross-flow membrane filtration technology is quickly gaining global acceptance as an important manufacturing step in many of the process lines in the food, dairy, pharmaceutical/biotechnology and, starch and sweetener industries worldwide. The ability to produce very specific separations at low or ambient temperatures with no phase change can, in many applications make membrane filtration a much more cost-effective solution than conventional methods such as rotary vacuum filtration or filter presses.

Membrane filtration is a pressure driven technology with pore sizes ranging from 100 molecular weight to 5 microns. The technologies included in membrane filtration are:

Reverse Osmosis (RO)

Reverse Osmosis is a high pressure, energy-efficient method of de-watering process streams, concentration of low molecular weight compounds or clean-up of waste effluents. Common applications include pre-concentration of dairy or food streams prior to evaporation, polishing of evaporator condensate, and purification of process water. Fig. No. 20.1 Shows Picture of Reverse Osmosis (RO).

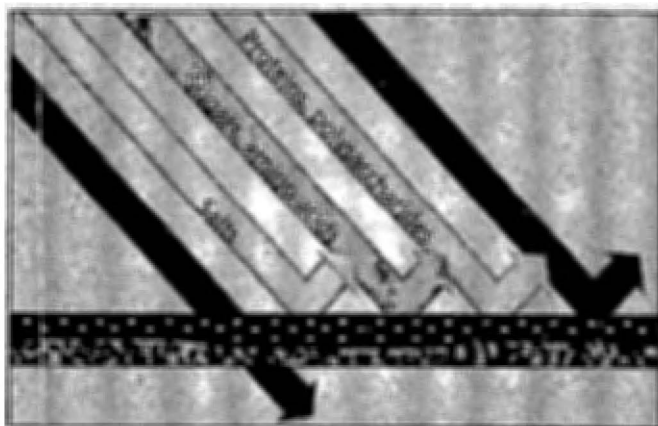


Fig. 20.1: Picture of Reverse Osmosis (RO)

Nanofiltration (NF)

Nanofiltration is a unique filtration process in-between Ultrafiltration and RO designed to achieve highly specific separations of low molecular weight compounds such as sugars from dissolved minerals and salts. Typical applications include de-ashing of dairy products, recovery of hydrolyzed proteins, concentration of sugars and purification of soluble dyes and pigments. Fig. No. 20.2 Shows Picture of Nanofiltration (NF).

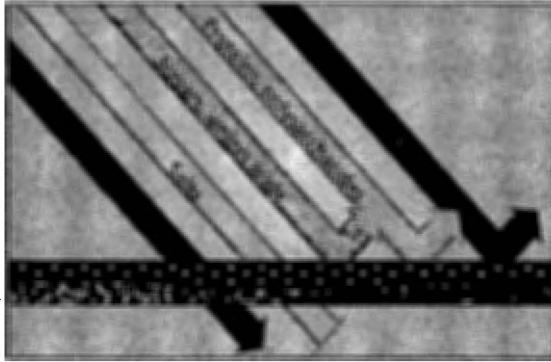


Fig. 20.2: Picture of Nanofiltration (NF)

Ultrafiltration (UF)

Ultrafiltration is a selective separation step used to concentrate and purify medium to high molecular weight components such as vegetable and dairy proteins, carbohydrates and enzymes. Common areas of application are whey protein concentration, gelatin de-ashing and concentration and clarification of fruit juices. Fig. No. 20.3 Shows Picture of Ultrafiltration (UF).

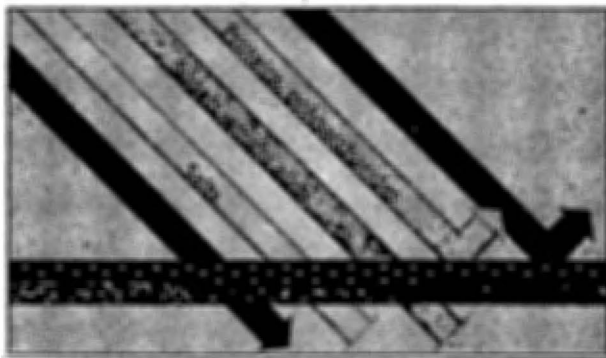


Fig. 20.3: Picture of Ultrafiltration (UF)

Microfiltration (MF)

Microfiltration is a low pressure means of separating large molecular weight suspended or colloidal compounds from dissolved solids. Applications include cell harvesting from fermentation broths, fractionation of milk proteins, corn syrup clarification and CIP chemical recovery. Fig. No. 20.4 shows Picture of Microfiltration (MF).

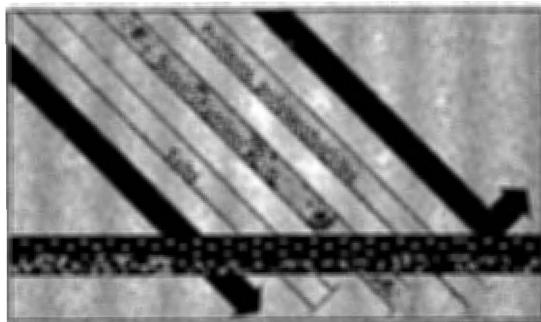


Fig. 20.4: Picture of Microfiltration (MF)

Uses of Membranes in Food and Dairy Industry

Membranes are used in a wide variety of applications : 1) Dewatering of waste streams, 2) Milk fractions separation, 3) Protein concentration, 4) Defatting of skim milk and whey streams, 5) Diafiltration of whey, and 6) Removal of bacteria from milk and whey.

An area in which membrane filtration has been used with success is certainly the dairy industry. After a hesitating start in the early nineties the number of applications has been growing rapidly, and still more plants have in practice proved the advantages of the processes, and in the last two years the sale of equipment and process lines based on membrane filtration has increased enormously.

Membrane Processing of Whey

The largest by-product of the dairy industry today is whey from cheese, paneer and casein production. As waste water, whey is highly polluting with a BOD value in the order of 50,000 mg oxygen. With increasing demands on the environments and consciousness on resources all over the world it is in most places no longer permitted to feed the whey to the sewage plant. Among the many suggestions, utilization of whey by membrane filtration seems today to be one of the most successful methods.

Hyperfiltration of Whey

By hyperfiltration it is possible to concentrate whey up to 20-22% total solids. In the process a nearly pure water is produced as a by-product. The BOD value of this water is normally between 25 and 300 mg oxygen per liter . The concentrated whey may be used as fedder or as a preconcentrate for production of whey powder or modified whey powders. By use of hyperfiltration it is possible to reduce cost on transportation and handling, evaporation and other processing.

Ultrafiltration of Whey

By ultrafiltration of whey it is possible to produce a number of protein concentrated whey products. The dry matter content of the concentrate from the ultrafiltration

plant will normally be between 12 and 20% solids depending on the actual process. If not used internally in the dairy, the product has to be spraydried.

Parallel with the production of the protein concentrated whey product, a new by-product called permeate is produced. It is roughly composed of water, lactose, salt and low molecular weight nitrogen compounds.

Whey protein powder with 35% protein has approximately the same composition as skim milk powder and is used as a replacer in product like ice cream or cereal products without reducing the quality of the products.

In normal ultrafiltration of whey it is possible to obtain up to 60-65% protein in solids. Protein powder with this composition shows valuable functional properties as water binding, gel formation and emulsifying ability. Protein powder with this composition is used as an ingredient in humanized baby food, is added to processed cheese, pasteurized cream cheese, and fresh cheese; and as an addition in meat industry.

Whey protein concentrates with 80% protein in solids can be produced by diafiltration. This means that water is added to the protein concentrate in the later stages of the ultrafiltration and thereby washing out salts and lactose. This latter product is a very valuable product with a high nutritive value and good functional properties. It finds its use among other things in dietetic products and in the bakery and meat industries.

Membrane Filtration In Indigenous Dairy Products

Various membrane processes have been applied for concentration of milk during manufacture of Indigenous dairy products. Four membrane processes are now in use in dairy industry include microfiltration (MF), ultrafiltration (UF), Nanofiltration (NF) and reverse osmosis (RO). RO and UF are widely used membrane processes.

It has great scope in the manufacture of many heat desiccated Indigenous dairy products such as *Khoa*, *Peda*, *Burfi*, *Rabri*, *Basundi*, *Kulfi* and *Kheer*. Dewatering is criterion of operation during manufacture of these products. Nanofiltration can also be applied particularly for *khoa*, paneer, and dahi. UF: Membranes are completely impermeable to microorganisms, lipids and proteins, substances bound with them. UF is applied for manufacture of *Chhana*, *Shrikhand*, *Dahi*, *Sandesh*, *Rasogolla* mix powder and *Paneer*.

Microfiltration: It removes suspended particles such as lipids, bacteria and spores from milk. It could be used to improve the microbial quality of milk intended for use in manufacture of Indigenous Dairy Products. It is that bacteriological quality and shelf – life can be extended by application of microfiltration. The bactocatch process is incorporated between the hot milk separator and the final heating section of the plate heat exchanger.

Reverse Osmosis: It is most energy effective dewatering membrane process which has been used for pre-concentration of milk at very low cost for the manufacture of some popular heat desiccated products.

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Chapter 21

Cleaning in Place (CIP) System

Many dairy equipment cleaning processes are now being conducted by recirculation techniques, utilizing a combination of chemical and physical effects to remove the soil from the product contacting surfaces. This procedure is referred to as a cleaning in place (CIP) operation and piping systems, valves, and process equipment susceptible to this technique are said to be of CIP design.

In-place cleaning is based on taking detergent to the equipment rather than taking the equipment to the detergent as has been the case with manually cleaned "take-down" lines. The effectiveness of the procedure is largely determined by the factors of time, temperature, detergency, and physical action involved. There are considerable benefits to be enjoyed through use of these products with particular emphasis on reduction of clean-up labor cost, improved sanitation of the complete system through the ability to use higher temperatures and stronger detergents, and the elimination of recontamination when assembling dismantled equipment.

In general, the development of a CIP program involves 7 steps. These include (1) the determination of process line requirements, (2) the development of CIP circuits, (3) the design of a suitable supply return system to clean these circuits and handle also all mechanical spray-cleaning operations, (4) the selection of materials of construction, (5) the making of the actual installation, (6) the selection and installation of recirculating equipment, and (7) the application of instrumentation and controls to assist in continuous maintenance of the desired cleaning program – and the desired results.

1. Process Line Requirements:

Layout of CIP lines for processing operations requires attention to numerous details such as (1) location and utilization of every pipe for both cleaning and processing functions, (2) permanent installation of the greatest possible amount of pipe, (3) elimination of all unnecessary bypass and return line connections, and (4) provisions to enable all processing to be completed without piping changes – yet permit quick conversion to the cleaning circuit. This type of planning demands considerable thought, but pays off in reduced product loss, improved sanitation, and savings in manhours of clean-up and processing labor.

Piping-system design can be started most effectively with the development of a process flow sheet showing all processing equipment and detailing all product-flow requirements for the various process operations involved. Attention must be given to the requirements

of potential simultaneous operation. It is necessary also to determine the order in which products will be handled, making allowances where necessary to clean portions of the system during the processing day if the product mix and anticipated production schedules so demand. If it is necessary to conduct product handling operations and cleaning operations simultaneously, engineering design should make it possible to do so without any physical connection between product containing systems and detergent-containing systems.

2. CIP Circuits:

After product piping requirements are established, the decision may be made as to the number of circuits to be provided to clean the total piping system. A single circuit is generally sufficient for small plants, whereas, larger plants will need several circuits, and possibly several recirculating units. If more than one circuit is desired, attention must be given to developing the best possible method for establishing CIP circuits which permit both efficient cleaning and processing operations to be conducted simultaneously. CIP circuits in a large plant might typically be established as follows:

1. Raw-milk lines from receiving room to storage tanks may be arranged to be cleaned independently of receiving operations.
2. Raw-milk and by-product supply lines to the HTST equipment (including raw-storage tank-discharge lines) may be cleaned upon completion of pasteurizing operations.
3. HTST units and associated piping may be cleaned after or simultaneously with the above lines.
4. Pasteurized-product lines to the surge tanks and from the surge tanks to the fillers may be cleaned as a single circuit upon completion of packing operations.

Spray cleaning of tankers, storage tanks, and vats is generally conducted separate from line and process-equipment cleaning operations. Spray methods can be classified into several categories including:

1. Water-driven rotary spray heads.
2. Water-driven oscillating spray heads.
3. Air-driven rotary spray heads.
4. Electric motor-driven rotary spray heads.
5. Removable fixed-conical spray nozzles.
6. Removable (portable) ball-sprays.
7. Permanently installed ball-sprays.

Permanently installed ball-spray units have become the most popular spray-cleaning fixtures. Spray devices have been developed for application in cleaning various types of processing or storage vessels. In selecting equipment of this nature, attention should be given to the following:

- i. The unit should be self cleaning and self draining.
- ii. The spray unit should be accessible for inspection and occasional cleaning of spray orifices.
- iii. Where spray cleaning of all tanks and vats in a given plant is intended, all sprays should be compatible with respect to operating flow rates and pressures to eliminate problems resulting from misapplication of pumps.

3. Supply Return System:

Recirculation cleaning operations require the use of a pump and solution tank for making up and recirculating and sanitizing solutions. Pumps and tanks may be built up in units mounted on casters so as to be portable for ease in movement about the plant. However, recirculation-cleaning operations require relatively large volumes of water and steam, and it is difficult to supply these utilities to portable recirculating equipment in adequate quantities. Further, considerable time is involved in disconnecting, relocating, and reconnecting CIP recirculating units.

A comprehensive CIP supply return line system provides a means of connecting a centrally located recirculating unit to any desired tank, vat, or process piping circuit to conduct in place cleaning operations. Typical systems make use of cleaning hook up stations or transfer plates for supply line connection and generally rely upon a swing elbow connection between the outlets of tanks and vats and a cleaning return line. Return pumps are located permanently as required to serve the various groups of tanks and vats, or a portable pump might be utilized for this purpose. CIP supply-return systems should be designed to permit cleaning procedures to be conducted without interference with product-handling operations.

A well-defined supply return piping system is essential to the efficient operation of "automated" CIP systems.

4. Materials and Connections:

CIP piping system may be installed using (1) bevel seat joints with special molded gaskets to provide flush interior surfaces, (2) bevel seat joints modified by "cutting" to use special-molded conversion gaskets, (3) Clamp-type CIP joints, and (4) "all-welded" joints.

Neoprene, Hycar, Teflon, and Silicone-rubber compounds are used for gaskets. Proper installation and operation of any joints gasket combination can provide satisfactory performance, and it is doubtful that any one joint is superior to any other under all conditions. In selecting joints, consideration should be given to a design for, (1) proper alignment of the gasket within the fitting, (2) minimum exposure of the gasket material to the product, and (3) a reasonably flush interior surface.

Welded stainless-steel lines are being more widely applied, and inert gas-welding techniques now available make it possible to achieve very smooth crevice-free interior weld surfaces. Special tubing and fittings are utilized. These items are extremely accurate and uniform with respect to wall thickness, diameter, and concentricity. Machine welding is preferable. Inspection ports, removable elbows, or removable inspection sections are generally included at various points in the circuits.

5. Installation:

Careful workmanship is essential to attractive appearance and proper performance of any CIP system. All lines must be properly fitted, properly pitched, and rigidly supported. Special attention must be given to the latter since proper support alone can assure maintenance of proper fit and pitch. Gaskets and joints which are protected from stress will be long-live and trouble free. Conversely joints subjected to strain because of vibration, lack of support, or poor fit will invariably cut, deform, and eventually fail completely.

However, it must be remembered that stainless steel has an appreciable coefficient of expansion, and long lines must be protected by applying swing elbows or making other provisions for some expansion movement. A long line anchored rigidly at each end can develop sufficient stress to distort a valve body, and repeated heating and cooling is accompanied by stresses that are detrimental to gaskets. All CIP lines should be pitched to drain completely to eliminate both product and cleaning solutions from the circuit. Commonly suggested standards for pitch range from 1/20 to 1/8 inch per foot. Continuity of pitch (freedom from sags and pockets) is perhaps more important than the exact degree of pitch employed.

6. Recirculating Equipment:

Solution Tanks

CIP solution tanks range in capacity from HTST constant level tanks to storage tanks of 5000 to 10,000 litres or more capacity. A solution tank must serve two functions, namely, (1) to provide the recirculating pump with a constant supply of detergent solution or rinse water, and (2) to serve as a place for introducing detergents into the system.

Small tanks can serve very well if an adequate supply of water is introduced into the tank to supply the pump during flushing and rinsing operations. Where hoses are used as a means of filling the tank (generally portable equipment), it is recommended that the tank be of sufficient size to contain 1 ½ times content of the line circuit to be cleaned.

Recirculating Units:

Portable recirculating units consisting of a solution tank, recirculating pump, and a temperature control and recording device may be moved around the plant for cleaning

several different circuits. However, permanently located tank-pump units can be more easily supplied with steam and water. A very satisfactory arrangement for plants using HTST pasteurization involves the utilization of a permanently located stainless steel tank pump unit as, (1) the heating recirculating unit for HTST pasteurization, (2) the recirculating unit for cleaning the HTST unit, and (3) the recirculating unit for cleaning the CIP piping circuits. Duplication of large size pumping equipment is thus eliminated, and automatic temperature control is available for all operations. Further, water, steam, power, and drainage facilities are generally provided in adequate quantities.

Where spray cleaning operations are to be conducted from the same recirculating equipment used for washing plate equipment and line circuits, a completely separate unit is generally necessary to prevent operation scheduling problems resulting from the necessity of cleaning storage tanks and processing vats while the HTST unit is in operation.

Pump Selection:

The physical effects of pressure and flow velocity contribute appreciably to the efficiency with which CIP cleaning operations are accomplished. Further, most regulatory agencies require the maintenance of a minimum velocity of 5 feet per second through all portions of the CIP system. Proper pressures and velocities can be best achieved by carefully working out pumping requirements and sizing the pumps for each specific application.

Only centrifugal pumps can be considered suitable for CIP purposes. These pumps can be classified by operating speeds as high speed (3,600 rpm) or low speed (1,800 rpm). Operating speeds under full load are normally 3,450 and 1,725 rpm respectively.

Pumps having enclosed or semi-enclosed impellers are smoother and quieter in operation than standard open-blade sanitary type pumps and, for this reason, are widely used in CIP cleaning systems.

Prior to selecting a specific pump, it is necessary to determine the total head loss for the CIP system on which the pump is to be applied. The total head loss in a CIP system is made up of the following separate components:

- i. Total static head of discharge above level of suction (generally negligible).
- ii. Pressure drop for equipment such as heaters, coolers, etc. at the CIP solution flow rate.
- iii. Friction loss through suction and discharge piping.

7. Controls

Every CIP system should include temperature indicating and recording equipment, since temperature and time play important parts in determining the efficiency of CIP operations. Records of these variables are of interest to the employee/employer, and

the public health official; generally the latter. A record of the temperature at any point in the circuit is generally sufficient as the relationships of temperatures at various points can be easily established. Automatic temperature controllers are helpful in maintaining the desired solution temperature throughout the feeding operation, and are mandatory for spray-cleaning operations to avoid overheating tankers and storage tanks. The simple self acting temperature controller is suitable and relatively inexpensive, though limited to a single temperature setting. Air operated temperature control systems make adjustment of cleaning temperatures easy. Alternatively, "on-off" temperature control at various levels can be achieved through the installation of temperature switches. "On-off" control has an advantage over "throttling" control for CIP operations in that steam mixing equipment is generally quieter and smoother at high steam flow rates. Further, the greater accuracy of the more complicated "throttling" type controllers is not required for CIP application.

Protocol for CIP

The actual method of cleaning and sterilizing the dairy plant with parameter's is given in chapter 25.

AUTOMATIC CIP SYSTEM.

The efficiency of CIP operations depends upon control of time, temperature, detergency, and physical action. Since such cleaning procedures are repetitive in nature, and certain spray-cleaning procedures (such as storage tank or tanker washing) are conducted many times daily in plants of average size or larger, the CIP process lends itself well to the application of automatic control.

The application of automatic control to CIP operations makes mandatory the application of two principles discussed; namely, (1) proper engineering of the product piping system and a CIP supply-return system, and (2) the installation of a permanently located recirculating unit. In addition to components described previously under recirculating Units, the automatic CIP system will include; (i) a program sequence controller to time all portions of the cleaning cycle, (ii) adjustable set-point temperature controls to provide variable supply line solution temperatures, (iii) air-operated solution flow-control valves, and (iv) detergent feed equipment to transfer chemicals automatically into the system as required for the different cleaning processes.

A completely automatic CIP system should include, in addition to timing and temperature control equipment, instrumentation to record supply-line temperature and supply-pump discharge pressure. Such records permit later evaluation of the system operation with respect to time, temperature, and hydraulic performance. Where desired, automatic CIP system may be electrically interlocked into process-control circuits to assure only proper operation and utilization of both.

Automatic Control

Application of air-actuated valving with process control by one of the two methods described, permits the development of the following control circuits which can handle operations automatically.

1. **High-level Cutoff.** When filling tanks or vats, excessive levels may be sensed through electrical probes or through pressure-sensitive switches in conjunction with liquid-level gages. Control circuits may then be established which will simultaneously stop the transfer pump, close the line valve, and sound an alarm advising the operator of the “full” condition.
2. **Low-level Alarm.** Probes or sensitive pressure switches may be similarly applied to provide advanced indication that a tank supplying an HTST unit or a filler is about empty, thus permitting the operator to stand by and switch tanks at the proper time. In addition, automatic controls may provide automatic diversion of the pasteurized product discharge from an HTST unit to the constant-level tank when the milk supply to the constant-level tank fails, thus avoiding “burn-on” and other problems associated with failure of the milk supply to a pasteurizing unit.
3. **Automatic Flushing.** The timing equipment may be employed to automatically flush a line free product with water, diverting water to a drain at the proper time. Such timing equipment may also be installed to help prevent intermixing of product in surge tanks when following one product with another during continuous pasteurizing operations.

Interlock Protection

Electrical primary control of process flow control valves permits establishment of “interlock” circuits which may protect against, (1) intermixing of product, and (2) intermixing of product and cleaning solutions during CIP operations. Interlock circuits of any desired form may be established to make certain conditions mandatory prior to the establishment of any product transfer or CIP cleaning operation. Further, interruption of these circuits during the process can cause operations involved to be stopped and placed in a “fail-safe” condition.

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Chapter 22

Energy Conservation through Technology Upgradation

Conservation of energy is an essential step towards overcoming the mounting problems of the worldwide energy crisis and environmental degradation. Countries like India are interested in increasing awareness of inefficient power generation and energy usage. However, a minimum of information on the rational use of energy is available.

Dairy industry consumes substantial amount of thermal energy for milk processing (pasteurization, clarification and homogenization) and (electrical) energy for milk chilling (before and after pasteurization), running of cold stores and producing compressed air for pneumatic milk packing machines. Heat treatment of milk and milk products is a very common and important unit operation in the dairy industry. It is done to ensure microbial safety of the end product and to increase shelf life. Steam, electric power and water are often used in the raw material processing stages of the production stage of dairy industry. Hygiene control, a common element in factories, is very important; Utilities include steam, cooling water, brine, compressed air, sterilized air and electricity. Alongwith the production process, wastewater treatment is also important. Most factories have storage, air conditioning and packaging equipment, and generators are fitted in case of power failure.

Excessive use of energy is usually associated with many industrial plants worldwide, and processing plants are no exception. Enormous potential exists for cost effective improvement in existing energy-using equipment. Also, application of good housekeeping measures could result in appreciable saving of energy. Therefore, it is imperative to introduce and disseminate information about modern energy saving technologies among the parties concerned especially at plant level.

Dairy plant operations are energy intensive, and fuel as well as electricity are among major controllable expenses. It is desirable to calculate energy consumption value for each operation and to have periodic energy audit. Comparison of actual consumption with norms enables monitoring of energy usage in the plant. Water conservation programme strongly affects the energy management in a dairy plant as large quantity of water (i.e., two litres per litre of milk) is used for cleaning and sanitation purpose and also large amount of it is used as a carrier of heat.

Heat in the form of steam and hot water accounts for about 80 percent of energy used in dairy plants. Steam distribution losses due to insufficient insulation and steam leaks further reduce the thermal efficiency. The thermal efficiency of steam production and distribution in a dairy plant is low as normally it does not exceed 50 percent. The conversion of fuel energy to steam energy depends on the fuel used, equipment employed and its efficiency, and skill of operating personnel. Electricity is used for lighting and to drive / run motors, conveyors, air and refrigeration compressor, fans and blowers, pumps and, office machines, etc. Share of production-related use of electricity rarely exceeds 50 percent. More than 50 percent of the electrical energy used in the processing operations is assigned to flow of milk and manufactured products. The other half is used to drive separators, churns, filling and packaging machines, etc.

The likely consumption of various services are given below:

Water:

Liquid milk plant	1 to 1.5 litre / litre of milk
Product dairy	1.5 to 2 litres/litre of milk

Power

1 kw/30 litres of milk

Furnace Oil/ Light Diesel Oil

1 litre/200 litres of milk

Steam

1 kg/6 litres of milk

Refrigeration:

Liquid milk plant	1 TR / 1,000 – 1,200 litres of milk
Product dairy	1 TR / 600 – 800 litres of milk

Powder plant of 10 tonnes / day capacity:

Fuel oil	1 litre / 2.5 kg of powder
Steam	5 kg / 1 kg of powder
Powder	1 kw / 3.51 kg of powder
Refrigeration	5 TR

Effluent treatment plant:

Volume	
Liquid milk plant	1.5 litre / litre of milk
Composite milk plant	2 litres / litre of milk

Biological Oxygen Demand

Liquid milk plant	1000 ppm
Composite milk plant	1200 to 1600 ppm
After treatment	30 ppm

This has reinforced the need for technology upgradation in the dairy plant operations so that products of uniform quality with high hygienic standards can be produced with minimum wastages. Good manufacturing practices (GMP) form an essential tool to control dairy wastes. However, to make it more effective, waste reduction through technology upgradation is the need of the day.

The energy conservation through technology upgradation can be considered under three areas:

- In various Utilities.
- In Processing and Product manufacture.
- In Milk packaging.

1. Energy Conservation in various Utilities

1.1 Electrical Energy

Electricity consumption contributes to the major costs in a dairy plant. The industrial electricity billing is normally done on the basis of actual units of electricity consumed plus the maximum demand charges. The maximum demand varies with the time of the day depending upon the various equipment in operation. The increase in industrial electrical tariffs puts pressure on dairies to minimize consumption thereby reducing the electrical bill. PLC based control system are available, which can be used to optimize the operating schedule of the equipment automatically, ensuring the maximum demand within the contracted limit. Following are some of the technological upgradations, which can contribute to reduction in electrical energy consumption.

a. High Efficiency Motors

Electric motors have been the main providers of motive power in the industry. Now a days, high efficiency AC induction motors are available. The efficiency level of these motors is about 3% higher than that of the standard AC induction motor. These motors can offer quieter and cooler operation, high reliability and longer life, increased profit from lower operating cost. Normally the motors are supplied by the original equipment manufacturer along with various equipment. Many a times, the end users are keen to purchase energy efficient motors, but are unwilling to pay a premium price as they are not confident of realizing the energy saving potential in their application.

An economic analysis for a 15 KW motor is given in Table No - 22.1 as guideline to the end users for selection of high efficiency motors.

Table 22.1: Analysis of Standard and Energy Efficient Motor of 15 KW

Parameter	Standard motor	Energy efficient motor
Price (Rs)	17,700	21,420
Efficiency (%)	89	91.8
Premium price (Rs)	-	3540
Annual operating period (h)	8000	8000
Energy cost (Rs. KWH)	4	4
Annual energy cost (Rs.)	5,39,326	5,22,876
Annual cost saving (Rs.)	-	16,450
Payback period (Months)	-	2.5
Recovery of entire cost of motor	-	1.3 years

b. A.C. Variable Frequency Drives

Generally there is over capacity in the selection of capacity of pumps/fans, as engineers tend to keep certain cushion during design stage to take care of unforeseen site conditions, pipe routing, layout changes, etc. The actual flow requirement for the process is often controlled by throttling valves. However, this affects the efficiency of the system. AC variable frequency drive units are available, which in conjunction with pressure/flow measuring device can automatically vary the speed of pumps/fans/compressor to suit the actual load requirement. These are much more economical than throttling valves/dampers to regulate the flow.

The energy saving potential of 30 KW Variable Flow Drive (VFD) as against throttling valve for pump application to control flow is presented in Table 22.2

Table 22.2: Comparison of Energy Saving Potential of VFD and Throttling Valve.

Flow (%)	Power Consumption (KW)		Energy Consumed Per Year (kwh/year)		Energy Cost Per Year (Rs.)		Yearly Cost
	Controlled by Throttling Valve	Controlled by Variable Frequency Drive (VFD)	Controlled by Throttling Valve	Controlled by Variable Frequency Drive (VFD)	Controlled by Throttling Valve	Controlled by Variable Frequency Drive (VFD)	Saving by Variable Frequency Drive (VFD) (Rs.)
90	28.17	24.28	246769	212692	987076	850771	136305
80	26.17	18.54	229249	162410	916996	649641	267355
70	25.62	14.04	224431	122990	897724	491961	405763
60	24.71	10.61	216460	92943	865840	371774	494066
50	24.03	8.01	210502	70167	842008	280670	561338
40	23.56	6.08	206385	53260	825540	214043	611497
30	23.33	4.73	204371	41434	871484	165739	705745

c. Building Automation

Building automation systems are also now being installed in many of the new office buildings. These computer based systems provide centralized controls and monitoring of building services such as air conditioning, hot water generation, lighting, mechanical plant, monitoring and alarm system as well as the centralized security. These days, presence detection system/occupancy sensors are available, which automatically switch on the lights, fan/air conditioners depending upon the occupancy of the room and help in reduction of power wastage.

1.2 Refrigeration

Refrigeration plant is the major utility, which consumes over 50% of the electrical energy of a typical dairy plant. Some of the technological developments in refrigeration equipment, which can help in reducing energy consumption, are as under.

a. Screw Compressors

The compressors are the heart of the refrigeration system, which have undergone continuous improvements over the years. Screw compressors with economizer unit offer the following advantages as compared to the conventional reciprocating type compressor:

- High Co-efficient of Performance (COP) and lesser power consumption.
- Stepless capacity controls to ensure accurate temperature / pressure control and thereby saving energy.
- Higher reliability with minimum maintenance requirement.
- Longer life.

However, these compressors being sophisticated ones, require great attention in terms of cleanliness of refrigerant system and vessels, use of right lubricating oil and strict adherence to preventive maintenance schedule.

b. PHE Type Condensers

Plate Heat Exchanger (PHE) type condensers are presently available, which are very compact in design due to higher heat transfer coefficient and consume less power and water. The capital cost of the PHE type is also lower than the atmospheric type condensers. A comparison between PHE type and atmospheric type condensers is made in Table 22.3.

Table 22.3: Design Aspects of PHE and Atmospheric Type Condensers

Design Parameter	PHE	Atmospheric
Capacity, Kcal/hr	363000	363000
Tonne of Refrigeration	120	120
Water flow, lit/hr	91400	200000
lit/sec	25.39	55.56
Head. In meter	24	16
Water Pumps, HP	12.5	20
Fan, HP	5	0
Total HP	17.5	20

To ensure longer operating life and to avoid deterioration of performance, good quality of water (chloride content <30 ppm) should be used.

c. PHE Type Pre-Chiller

A combination of PHE type Pre-chiller and conventional IBT is presently being incorporated in chilled water system (Fig. No - 22.1). The chilled water returning from the process is pre-chilled to about 2°C before entering the IBT. Due to the higher heat transfer coefficient provided by PHEs, the requirement of ice bank coil length comes down, which result in smaller IBT size and lesser capital cost as compared to conventional system of same capacity.

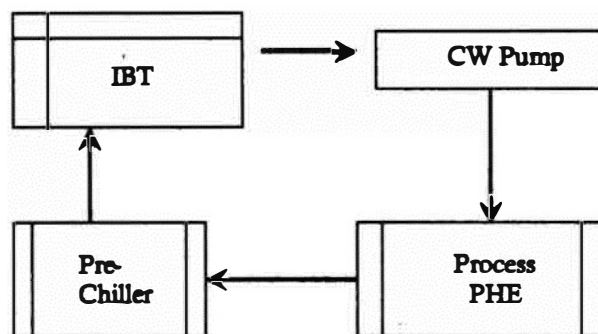


Fig. 22.1: Combination of PHE Type Pre-Chiller & Conventional IBT.

Since, evaporation temperature required for pre-chiller is -2°C , as compared to -10°C for IBT system, the system COP improves considerably and thereby saves electricity consumption by about 27% as is evident from Table No. 22.4

Table 22.4: Saving in Electricity Consumption for PHE Type Pre-Chiller.

Suction temp. (C)	Specific Vol. of NH_3 (lit/kg)	Refrigeration capacity (TR)	Power consumption (KW)	COP	% increase in COP (baseline-10 C)
-2	310.73	113.98	95.5	4.20	27.1
-6	359.66	95.07	89.8	3.72	12.7
-10	418.23	78.44	83.5	3.30	0.0
-11	451.82	74.54	82.0	3.20	-3.2
-12	488.74	70.73	80.4	3.09	-6.3
-13	529.36	67.09	78.8	2.99	-9.4
-14	574.13	63.56	77.2	2.90	-12.3
-15	623.56	60.15	75.5	2.80	-15.2

d. Air Cooling Units with SS Tubes

Air cooling units with stainless tubes and aluminium fins are available presently. Though the price of these units is comparable with galvanized steel air cooling units, they offer following advantages:

- Compact in size; therefore occupy less cold room space.
- Weigh only about 40% of the conventional galvanized type. Air Handling Units (AHU), therefore save cost of transportation, installation and supporting civil structures.
- Refrigerant charge is lower by about 35%.

- i. Use of automatic shut off devices on all water hoses of steam and water mixing batteries.
- ii. Use of high pressure, low volume cleaning systems for cleaning crates, silos, etc.
- iii. Use of recuperation tanks as a part of the CIP system recovering the hot water for reuse as pre-rinse in the next CIP cycle
- iv. Use of automation for CIP system and other operation. It is reported that in an automated dairy plant a saving to the tune of 20-25% has been achieved in the expenditure on water supply.
- v. Use of continuous rather than batch processes to reduce the frequency of cleaning.
- vi. Use of level controllers switching on/off the pumps to avoid overflow from tanks.
- vii. Use of automatic shut off valves with photo sensors for wash basins / urinals.

1.4 Compressed Air

Lubricated / oil free reciprocating air compressors are generally used in dairy plants for supplying compressed air. However, now screw compressors are being preferred over reciprocating compressors in case of varying load, because the full load power requirement of screw compressor ranges from 0.35 – 0.40 kw/lit/sec as compared to 0.38 – 0.43 kw/lit/sec in case of single stage reciprocating compressors. The power reduction in the compressed air system can also be reduced by providing pressure reducers at each point of use and by adjusting the operating pressure of the compressor slightly higher above the highest pressure required for use.

2. Energy Conservation in Processing and Product Manufacture

2.1 Bulk Milk Cooler

Bulk milk coolers are now being used for chilling milk at a village dairy cooperative society/collection point which prevents souring of milk in summer season and minimizes fat & SNF losses, besides improving milk quality. The bulk milk coolers with direct expansion system consume about 15% lesser power as compared to chilling of milk using conventional Ice Bank System.

2.2 Milk Processing

The Pasteurization plants are designed for 90% regeneration efficiency. However, in case of automated dairies, the regeneration efficiency can be achieved upto 93%. The reduction in utility consumption for a 10000 litres/hr milk pasteurization plant with 85%, 90% and 93% regeneration efficiency is shown in Table No - 22.5.

INITIAL AND RUNNING COST COMPARISON OF ABSORPTION AND COMPRESSION SYSTEMS FOR CHILLING 100000 LITRES MILK PER DAY

A) INSTALLED POWER REQUIRED

Compressor based system.....	310 kw
Aqua ammonia absorption system.....	75 kw

B) INITIAL COST:

Compressor based system.....	Rs. 42,00,000
Absorption based system.....	Rs. 35,00,000

C) Running cost per year:

a) compressor based system:

Power cost per year.....	Rs. 21,00,000
Service and spares cost per year.....	Rs. 1,00,000
Total cost per year.....	Rs. 22,00,000

b) Aqua ammonia absorption system:

Power cost per year.....	Rs. 4,60,000
Steam cost per year.....	Rs. 16,00,000
Service and spares cost per year.....	Rs. 20,000
Total cost per year.....	Rs. 20,80,000

Basis of calculation:

No. of hours of operation per year.....	5000
Power cost per kwh.....	Rs. 4.10
Steam cost per kg.....	Rs. 0.40

1.3 Steam

World's energy resources like oil, gas, coal, etc are fast depleting and also getting costlier. The limited energy resources put pressure on the industries to tap various renewable energy resources to minimize the dependence on these conventional fuels, as the same are not going to last forever.

a. Solar Water Heating System

Solar energy is one of the promising renewable energy sources, which is freely available in abundance. Moreover, it is eco-friendly, as there is no emission of green house gases. Most part of India is receiving solar radiation @ 5 kwh per day/m². Solar energy for various heating application is already being used in some of the dairy plants for reducing the fuel bill. Hot water upto 80°C temperature can be obtained from solar water heaters, which can be conveniently used for crate washing, can washing, CIP system, preheating boiler feed water, etc.

b. High Efficiency Boilers

In the steam raising plants, the efficiency of the oil fired boilers with high / low flame burners is generally between 86 to 88%. However, by using the continuous modulating burners, the thermal efficiency of these boilers has been improved to 90%, thereby reducing fuel cost and also conserve fossil fuel.

c. Air Heaters

In spray drying plants hot air is required for drying milk, which is heated with the help of steam radiators or thermal oil radiators. However, 10 to 15% energy saving can be achieved by using directly fuel fired air heaters in place of steam radiators and 15 to 20% saving by replacing thermal oil radiators.

d. Hot Water Based Heating System

Energy losses in conventional steam distribution system on account of steam leakages and condensate drain is about 30% in a typical dairy plant. This can be reduced to a large extent by using hot water based heating system in place of steam boilers. Since the hot water heating system operates at relatively lower than those of steam boiler pressure, it is not covered under the purview of Indian Boiler Regulation (IBR). The initial cost and operating cost of the hot water systems are also relatively lower than steam boiler. Since the circulation of hot water is in a primary and secondary closed circuit, there is no recurring cost of makeup water.

1.4 Water

Water has many uses in dairy processing for cooling, washing, heating and cleanup. In the early seventies, we used to consider water usage as 3 liters to process one litre of milk.

Water and effluent treatment cost has been increasing rapidly and these can cut into profits. However, using water more efficiently, increasing cost can be counter balanced. Realizing the potential for savings, some plant managers have been continuously cutting down their plant's water use to as low as 1.3 to 1.5 litre of water per litre of milk processed. In large automated dairies, water consumption is aimed at keeping at about 1 litre per litre of milk processed.

Cutting water use has a double benefit: it not only lowers the plant's water or energy bill, but also helps to reduce the effluent treatment cost. Besides cost savings lesser use of water also helps to operate the plants under drought conditions.

Substantial water wastage can be reduced through GMP and these efforts can be supported by using the following technological innovations:

- Less energy consumption due to shorter defrosting cycle.
- No corrosion and therefore longer life.

c. Fanless Cooling Towers

Fanless induced draught jet type FRP cooling towers are another innovation. The air movement in this type of cooling tower is created with the help of a water jet, which eliminates the need for a fan to create the air draught and thereby results in saving power. Since there are no moving parts, the maintenance required is minimal and also prolongs the life of the cooling tower.

AQUA AMMONIA ABSORPTION REFRIGERATION PLANTS

In an aqua-ammonia absorption cycle, the absorbent aqua ammonia liquid absorbs the ammonia vapours from the chiller. The resultant aqua ammonia strong solution liquid is then pumped to the higher pressure using a pump and a small electric motor. Being compressible, compression of gas is more energy intensive compared to liquids which are generally incompressible and can be compressed using a pump. The high pressure liquid is then heated to release the absorbed ammonia back to the condenser. The heat is usually from steam (as in most industries, steam is easily available), but in practice it can be in any other form of heat.

Advantages:

- Reduction in dependence on electricity upto 90% with very little maintenance and spares requirement.
- Subzero temperatures right up to minus 30°C possible without going in vacuum.
- Flexibility in desired temperature possible without going in vacuum.
- Flexibility in desired temperature possible without reduction in plant capacity.
- Simple, noiseless and vibration less operation.
- Application possible in all areas where refrigeration is required such as Chemical industries, Pharmaceutical industries, Dairies, Breweries, Ice plants, Cold stores, Other food industries.

Absorption system of refrigeration uses low grade energy-heat whereas compression system needs high grade energy-electricity. It must be our endeavor to make the best use of available energy resources and hence minimize usage of high grade electricity for a low grade application such as chilling milk. Most dairies already have ammonia refrigerant based refrigeration system. Hence it would be logical and simple to couple an aqua ammonia refrigeration system with available steam and save precious electricity.

Table 22.5: Utility Consumption of Milk Pasteurization Plant.

Regeneration Efficiency (%)	Steam Requirement		Chilled Water Requirement		Total Running cost (Rs.)
	Kg/hr	Running cost per day –(8 hrs shift)(Rs.)	TR / hr	Running cost per day –(8 hrs shift)(Rs.)	
85	203	974.4	35	2100	11,22,156
90	135	648.0	23	1380	7,40,220
93	95	456.0	16	960	5,16,840

2.3 Self Cleaning Separators

In the conventional manual cleaning type milk separators, the fat content in skimmed milk is in the range of 0.05 to 0.1% when measured by Gerber method. The fat content when measured by Rose Gottlieb method lies in the range of 0.1 to 0.15%.

In self cleaning separators, the fat content in the skimmed milk is about 0.05% by Rose Gottlieb method, which thereby helps minimizing the fat loss and improves profitability of the dairy operation. By using self cleaning separator, the fat loss in skimmed milk could be brought down to about 0.08%. The following example illustrates the cost saving potential of a 10 KLPH self cleaning separator, worked out at the rupee value in 2011.

- Fat loss per hr 8 kg
- Fat loss per day (16 hrs per day) 128kg
- Fat loss per year (240 days) 30720 kg
- Approx. cost of fat loss per year Rs. 30,72,000/-

2.4 Auto Standardization Unit

Auto– standardization unit plays an important role in minimizing the losses of valuable fat and SNF in dairy processing. Online analyzing and auto corrections make it possible to blend fat and SNF accurately and uniformly (standard deviation is about 0.01%), which is not possible using traditional batch operation methods.

2.5 Process Automation

In manually controlled processes, achieving uniform product quality, optimizing utility consumptions and minimizing waste reduction solely depends on the skill, judgment and alertness of the operators. Since human beings are prone to errors, manually controlled processes cannot be fully relied upon for ensuring optimum utilization of services and reduction of wastage. Automatic controls like PID controller, flow controllers, etc., can replace manual controls for timing and controlling heating and cooling processes. These controls not only reduce the costly energy wastages, but also produce the added bonus of improved and uniform product quality, reduction in process

losses, high degree of hygiene, increased productivity and flexibility, reduction in manpower requirement, etc.

Most of the new larger capacity plants are having considerable amount of automation for various processes. These fully automated plants are operated from a centrally located control room, based on the sequence of logics already programmed and stored into the PLC. The flow rates are measured by magnetic flow meters. The mass flow meters measure the quantity of milk receipt and dispatches. The field instruments like sensor and transmitters measure the temperature, pressure, conductivity, pH; etc. Some of the existing dairy plants have also adopted automation for some of the processes and have achieved considerable saving as illustrated in Table No 22.6.

Table 22.6: Saving Through Automation in Dairy Plant

	Particulars	Before Automation	After Automation	Savings (%)
Plant - 1	Water consumption (litre/litre of milk processed)	2	1.5	25.0
	Electricity consumption (Kwh/1000 litres of milk processed)	38.67	38.46	0.5
	Fluorace oil consumption (litre P.O. / 1000 Litres milk processed)	2.6	2.28	12.3
	Product losses (%)	0.95	0.65	32.0
Plant - 2	Water consumption (litre/litre of milk processed)	2.1	1.9	9.5
	Electricity consumption (Kwh/1000 litres of milk processed)	37.5	37.02	1.3
	Fluorace oil consumption (litre F.O./1000 Litres milk processed)	8.99	7.48	16.8

2.6 Continuous Process Lines

Use of continuous process line rather than batch process reduces the frequency of cleaning and utility consumption.

a. Continuous Khoa Making Plant

NDDB has developed mechanized system for khoa manufacturing which has several advantages over conventional method. The comparison of cost and utilities involved in various methods of khoa manufacturing is shown in Table No - 22.7.

Table 22.7: Comparison of Cost and Utilities Involved in Various Methods of Khoa Making

S/No.	Manufacturing method	Cost of Labour/kg of Khoa (Rs.)	Cost of Utility/ kg of Khoa (Rs.)	Cost of Labour + Utility / kg of Khoa (Rs.)
1	Wood fired chulah/stove	4.17	6.38	10.55
2	Wood and kerosene fired chulah / stove	3.13	10.63	13.79
3	Steam jacketed open pan	6.49	7.20	13.90
4	Diesel fired stove	2.21	12.60	14.81
5	NDDDB designed khoa line	1.51	3.07	4.58

b. Continuous Curd / Misti Doi Manufacturing Plant

Unlike the conventional batch process, in the continuous curd/misti doi manufacturing process, the regeneration of heat is possible which saves considerable processing cost and energy. This process also helps to manufacture consistently good quality and longer shelf-life products due to better control of process parameters and hygienic conditions.

c. Continuous Butter Churns

Continuous churns or continuous butter making machines of capacities ranging from 800 kg to 10,000 kg/hr are available. These machines not only produce butter with superior quality in taste, texture but also have following added advantages:

- They are energy efficient.
- They produce butter having low moisture content.
- They reduce losses of fat in butter milk.

2.7 Milk Evaporation Plant

The cost of steam required for evaporating and spray drying plants contributes significantly towards the operating costs of these plants. The vapour coming out of the evaporators contains significant heating value as latent heat of vaporization. This energy can be recovered by heat recovery techniques or by using multi-effect evaporation. The vapour can also be reused in the same unit if the temperature and pressure of the vapour steam are increased to the conditions existing in the steam chest. The methods used are:

- Thermal recompression.
- Mechanical recompression.

Through continuous upgradation of technology, efforts have been made in the past three decades to reduce steam consumption. The reduction in the specific steam

consumption in the evaporating plant with single effect, double effect, triple effect and five effect plants is given in Table No - 22.8.

Table 22.8: Comparison of Specific Steam Consumption in Multi Effect Evaporation Plants

S/No.	Type of Plant	Temp. Difference at Vapour Compressor	Specific Steam Consumption (Kg of steam / kg of water evaporation)	Evaporating Capacity (kg/hr)
1.	Single Effect	-	1.1	500
2.	Double Effect	15 C	0.4 – 0.45	1500 – 3000
3.	Triple Effect	10 – 12C	0.25 – 0.30	5000 – 16000
4.	Five Effect	8 C	0.14	16000 – 40000

New evaporators are being equipped with instrumentation and measurement devices necessary to allow the operators to monitor closely the performance of evaporators and to minimize energy use. For example, in a 60 TPD powder plant, by using conductivity meter, the condensate to the tune of 7000 lit/hr from Ist stage is recovered while manufacturing SMP.

2.8 Two Stage Drying

The latest powder plants in our country are the two stage drying type where the moisture content in the first stage (within drying chamber) is reduced to 7% and then further reduced to 3% in the second stage (Vibro-fluidizer).

The distinct advantage of the two stage drying plant is that it consumes 10% less heat in comparison to the single stage dryer. In case of two stage powder plant, there is also a possibility to limit the stack loss to 0.1%. The economy can be further improved by increasing inlet air temperature or feed concentration.

2.9 Three Stage Dryers

Three stage spray dryers are also available and are reported to produce high quality powders with low energy consumption.

In case of three stage dryer, the second stage fluid bed is built into the cones of the drying chamber. The external fluid bed (static / vibrating) forms the third stage for final drying and /or cooling.

2.10 Bag Filters

Sanitary bag filters are also being used in other countries to receive the powder fines escaping through the exhaust air from cyclone separators.

3. Energy Conservation in Milk Packaging

3.1 Pouch Filling Machine

Milk pouch packaging machines have undergone technical improvements over the years. One significant development is the mechanical type machines with PLC based controls. These machines not only offer substantial savings in electricity consumption as compared to conventional pneumatic type machines on account of elimination of compressed air requirement, but also provide better filling accuracy, minimum leakages and higher productivity thereby help to reduce product losses. The cost saving potential of the mechanical type FFS machine as compared to pneumatic type machine is given in Table No - 22.9.

Table 22.9: The Cost Saving Potential of FFS Pouch Filling Machines

Particulars	Pneumatic Type FFS Machine	Mechanical Type FFS Machine	Saving
Power Consumption			
Power requirement for the FFS machine	2 KW	3.5 KW	(-) 1.5 KW
Power requirement for the Air Compressor	5 KW	0	5 KW
Total Power requirement	7 KW	3.5 KW	3.5 KW
Cost of electricity consumption per year (considering 12 hrs operation per day & electricity cost @ Rs. 4/- per kwh)	Rs. 1,22,640/-	Rs. 61320/-	Rs. 61320/-
Product Losses			
Filling accuracy	+ 5 ml / pack	+ 2 ml / pack	3 ml / pack
Number if 500 ml packs filled per year (@ 50000 pack/day)	1,82,50,000 Packs	1,82,50,000 Packs	-
Quantity of excess filled milk due to filling inaccuracy	91,250 litre	36500 litre	54750 litre
Cost of excess filled milk (@ Rs. 10/- per liter)	Rs. 9,12,500/-	Rs. 3,65,000/-	
Net saving by using mechanical type FFS machine in a year.			Rs. 6,08,820/-

3.2 Packaging Film

Presently LDPE/LLDPE based and coextruded polyfirm in 3 layers with thickness of 50 ± 5 microns for 500 ml pack and 60 ± 5 microns for 1000 ml pack is used. With technological developments in the blown film process, coupled with availability of high performance polymers, it would now be feasible to manufacture high strength, good quality film, with minimum thickness variation. This will not only help in down gauging of the packing film thickness and reduce film consumption by about 20%, but also have the following added advantages:

- The on-line, dock and transportation / handling leakages will be negligible due to high strength performance polymers.
- Consistently higher yield and productivity can be achieved resulting in overall packaging cost reduction.
- Lower environmental load as lower polymeric contents go into the manufacture of the milk pouch.

There is wide scope for economies in the use of fuel and this should be continually borne in mind by efficient plant operator. To some extent the efficient operation of a dairy can often be assessed by noticing the number of leaky steam valves in a plant which is indicative of slack management. All pipe lines other than those containing mains water should be adequately lagged and maintained in good condition. In the interest of economizing on fuel and power charges wherever possible, the calories expended in heating or chilling should be utilized to the maximum. Hot water in the form of condensate if unable to be used for product heating or some other purpose in the dairy can usually be returned to a boiler feed water tank. Cool room doors should be close fitting and not be left open unnecessarily. Boilers should not be left with a full head of steam at the finish of a shift. Machines should not be left running after they have completed their duty.

Energy Conservation in the Dairy Industry is possible by adopting advanced processing technology; scaling up of traditional processes; use of microprocessor-based controls; training of staff to identify, monitor and control the sources of loss; setting of targets for yield/output and focusing on achievements and increasing general awareness; implementation of corrective actions; operating plant at its maximum designed capacity; monitoring of waste as a routine check on the effectiveness of corrective action / program and effective management.

Chapter 23

General Hygiene in a Dairy Plant

Maintenance of general hygiene in a dairy plant is of paramount importance. However, it requires that a dairy plant is properly designed or modified so as to facilitate the day to day and periodic cleaning. If general hygiene is scrupulously maintained at every level even a seemingly old-fashioned dairy plant can produce excellent results in terms of quality products. The important points for general hygiene are given below.

1. Surroundings

- 1.1. The premises should be kept clean and should have defined curtilage. All the roads in the premises should be concreted / tarred or turfed to prevent wind blown dust.
- 1.2. There should not be any swamps, stagnant water or signs of any rodent harbourage inside the premises.
- 1.3. The surroundings should be free from objectionable odours, smokes, dust and other contaminants.

2. Layout and Construction

- 2.1 The immediate surrounding of the building should be tarred/ concreted to prevent contamination from the surroundings.
- 2.2 The establishment should be housed in a building of permanent nature affording sufficient protection from the environment and should be of sufficient size for the work to be carried out under hygienic conditions. The design and layout should be such as to preclude contamination.
- 2.3 The layout of different sections should be such as to facilitate smooth and orderly flow of work and to prevent possible cross contamination and backtracking. All the milk products handling areas should be separate from areas used for residential and unrelated purpose.
- 2.4 There should be adequate lighting and ventilation and light fixtures should be protected with proper covering.
- 2.5 The layout should ensure sufficient space in different sections for machinery, equipment, personnel etc., without congestion.
- 2.6 The building should provide sufficient protection against the entry of birds, dogs, monkeys, stray animal, rodents, insects etc.

- 2.7 All the entry points should have suitable air curtains or other suitable arrangements to prevent the entry of flies.
- 2.8 Wood should not be used in the factory, except inside the cold storage.
- 2.9 Non-operative areas inside the establishment should be properly cordoned off to avoid possible cross contamination.

3. Milk Receiving Section

- 3.1 There should be a raised platform for receiving the material and the sides and roof of the platform should be sufficiently protected from extraneous contamination.
- 3.2 The raw milk receiving section should be sufficiently separated from processing area to prevent contamination
- 3.3 Signboards should be installed directing the employees to wash and sanitise hands before entering and after each absence.
- 3.4 Air curtains/fly killers should be installed to prevent the entry of flies when the door is opened.

4. Workers' Wash Basins

- 4.1 Suitable washing and sanitizing facilities for feet and hands should be provided at the entry points.
- 4.2 The washbasins should be provided with foot operable taps or non-hand operable taps.
- 4.3 Liquid soaps, disinfectants, nailbrushes, single use towels / hand dryers etc., should be provided in sufficient quantities at all entry points.
- 4.4 Waste bins provided for collecting used towels should be of foot-operated type.

5. Floors, Walls and Ceilings.

- 5.1 The floor of the processing areas should be smooth, impermeable and easy to clean and disinfect. There should be no water stagnation on the floor. The floor should have sufficient slope opposite to the flow of work or side ways.
- 5.2 The wall to floor and wall-to-wall junctions should be rounded off to facilitate easy cleaning.
- 5.3 The walls should be durable, smooth, light coloured and easy to clean and disinfect.
- 5.4 The walls should not have projections and all the fittings on the wall should be made in such a way so as to clean and disinfect them easily. If possible, the electric switches or other fittings should be fixed in other areas where no handling of milk product is carried out.
- 5.5 The ceiling should be free from cracks and open joints and should be smooth and easy to clean.

5.6 If structural elements or fittings are suspended below the ceiling, suitable protection should be given to prevent falling of debris, dust or droppings.

6. Doors, Windows and Ventilators.

6.1 All the doors should be tight fitting and the windows and ventilators should have fly proofing nets to prevent the entry of flies.

6.2 All doors and windows should be durable and made of corrosion resistant material and window-sills, if any, should slope inwards. The windows/ ventilators should be constructed at least one meter above the floor.

6.3 The doors should be of self-closing type.

6.4 Mechanical ventilation/ exhaust fans should be provided in areas where stagnation of air, condensation of fluid etc., are present.

6.5 The opening of ventilation/ exhaust fan should be provided with suitable fly proofing arrangement.

7. Drainage

7.1 There should be adequate drainage facility and slope of the drainage should be opposite to the flow of work/material.

7.2 The open end of the drainage should be protected against the entry of rodents.

7.3 The drains should be of adequate size having sufficient slope for easy cleaning.

8. Tables, Utensils, Equipment and Machinery

8.1 All the utensils and equipment should be made of non-corrodible material without cracks and crevices and easy to clean and disinfect.

8.2 All food contact surfaces should be free from rust and paints.

8.3 Suitable arrangements should be made to drain the water from the tables directly into the drainage without falling on the floor.

8.4 Freezing equipment should be suitable to freeze milk products and should achieve the required core temperature within the stipulated time. The equipment should be fitted with necessary gauges to indicate the temperature, pressure, etc. The recording devices should be calibrated at specified intervals.

8.5 Pasteurisers of suitable capacity having capability to maintain required temperatures and time should be provided with automatic calibrated temperature devices.

8.6 Milk products store rooms should be clean having smooth floor, walls and roof and should have suitable mechanism to control the temperature, if required.

8.7 Spray drying facility should be equipped with approved air filters and the food contact surfaces should be smooth, easy to clean and made up of non-corrosive material.

9. Chill Rooms/Cold Stores

- 9.1 Chill rooms/storage tanks having adequate size with mechanical refrigeration system to maintain temperature at the required level (0°C to 4°C) should be provided in the processing section.
- 9.2 The floor, ceiling and walls of the cold storage and other storage rooms should be smooth and easy to clean and disinfect.
- 9.3 Proper steps should be taken to avoid contamination of the materials stored.
- 9.4 There should be adequate lighting with protective covers.

10. Change Rooms & Toilets

- 10.1 Adequate number of change rooms for workers should be provided for high risk and low risk areas.
- 10.2 The change rooms should be of adequate size having smooth washable walls and floors.
- 10.3 The lavatories should be flush type and not opening directly into working area.
- 10.4 The toilets should have self-closing doors and proper fly proofing system.
- 10.5 The change rooms should have foot-operated washbasin provided with adequate soap, nail brushes and single use towels. There should be a foot operated waste bins to collect the used towels.
- 10.6 There should be lockable cupboards and facility for keeping gum boots, shoes and chappals, etc., inside the change room.
- 10.7 Suitable arrangement should be made by the establishment for laundry/washing clothes and gumboots, etc., given to workers.

11. Store rooms.

- 11.1 There should be separate stores for wet and dry items and the chemicals/ disinfectants should be properly labelled.
- 11.2 Packing material store should be of adequate size with proper fly and dust proofing system.
- 11.3 Cartons should be kept on cleanable pallets other than wood, away from the walls and covered properly. There should be enough space for a person to walk around.
- 11.4 Pest and rodent control measures should also extend to the storerooms.

12. Water

- 12.1 Potable water should be used in dairy plants.
- 12.2 Potable water should be used also for cleaning utensils, machinery, tables, etc.
- 12.3 A suitable water management system should be followed and this should include use of plumbing diagrams showing the entire reticulation of the water, identifying each tap with consecutive numbers.

- 12.4 Water storage tank, both ground level and overhead, should be protected and cleaned regularly.
- 12.5 The taps having hose connections should be fitted with non-return valves.
- 12.6 The water tanks should be cleaned regularly as per predecided frequency.
- 12.7 If road tankers are used for bringing water, they should be cleaned and disinfected periodically.

13. Personal Hygiene

- 13.1 The employees engaged in processing activities should be free from communicable diseases, open sores and wounds.
- 13.2 They should be medically examined periodically and should maintain individual health cards issued by an approved medical officer showing that they are fit to handle food products and suitable to work in milk processing plant.
- 13.3 Prophylactic injections should be administered to the employees and records maintained thereof.
- 13.4 Communicable diseases in their homes to be notified and the employees should be medically examined after each absence due to illness.
- 13.5 All workers should be provided with sufficient sets of work dress.
- 13.6 A person should be made responsible for maintenance of personal hygiene of the workers.

14. In-house Laboratory

- 14.1 The establishment should have a well-equipped in house laboratory for testing microbiological and other chemical parameters.
- 14.2 The testing should be done by competent Technologist/Veterinarian.

15. Transportation

- 15.1 The establishment should have suitable and adequate facilities for the transportation of raw material, finished products, etc.
- 15.2 The food contact surfaces of the vehicles should be smooth, made of non-corrosive material and easy to clean and disinfect. They should be cleaned properly before loading and after unloading and the records maintained thereof.

16. Maintenance

- 16.1 There should be a documented procedure for maintenance of all sections, equipment, machineries, etc.
This involves good house keeping wherein detailed schedules are worked out to clean various facilities from time to time as per laid down procedures.
- 16.2 The machineries/equipment should be marked with suitable identification numbers.

17. Workers' Safety

There should be awareness amongst employees to take various precautions so as to prevent all types of accidents involving fire, electric shock, explosion, short circuit etc.

Chapter 24

Effluent Treatment in a Dairy Plant

Waste is the same as product loss. Product loss decreases the profit and increases the environmental impact. A substantial problem arising in dairy industry is the disposal of the waste water which is incidental to the various processes. An average volume of 2 litres of water is generally required for 1 litre of milk handled in a dairy. Effluents from dairies and factories manufacturing milk products may contain appreciable quantities of milk constituents like casein and other milk proteins, lactose, fat and inorganic salts. In milk these are present either in solution, in colloidal suspension, or as an emulsion, but in an effluent, the state in which they occur will depend on the treatment to which both the raw material and the effluent are subjected before they are discharged.

The polluting load of dairy effluent varies according to products handled, various operations carried out and house-keeping practised. It consists mainly of the unrecoverable raw-materials carried in the processed waters from spills, leaks and washings in various dairy plant operations. Normally, it includes substantial concentration of Fat, Milk Proteins, Lactose, Lactic Acid, Minerals, Detergents and Sanitizer. Majority of the pollutants are in a dissolved organic form and the pollution level is generally measured in terms of Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD).

Dairy Waste Water: Dairy waste water includes wash water from milk cans, tankers, process equipment, pipelines and floors, portions of spilled milk, spoiled milk and milk leakage from milk pumps, overflow and spillage. This can be further divided into three categories: cooling water, sanitary waste water and industrial waste water.

- i) **Cooling Water:** In dairy industry water is used in various utilities such as cooling tower, boiler, water softener, back-washing and air compressor. As cooling water is normally free from pollutants, it is discharged into the storm water piping system without any treatment.
- ii) **Sanitary Waste Water:** This includes water used for cleaning of milk cans, tanks and tankers, dairy floor, etc. The sanitary waste water is normally piped directly to the sewage treatment plant with or without first being mixed with industrial waste water. The effluent generated is high in volume and contains higher organic load.
- iii) **Industrial Waste Water:** Industrial waste water arises from acidic, curdled milk, discharge of sour whey, spillage of milk and products thereof and from cleaning of equipment (CIP) that has been in contact with milk products. The concentra-

tion and composition of the waste depends on the production programme, operating methods and the design of the processing plants. The effluent generated is highly unstable in nature and biodegradable.

It is essential that the waste water from the dairy has to be suitably treated before disposal. The Characteristics of raw dairy effluent and minimum national standards for dairy waste after treatment are given in Table No– 24.1.

Table 24.1: Characteristics of Raw Dairy Effluent

Parameter	Range	Limits (Max)
pH	7.0 – 10.5	6.5 – 8.5
TDS (mg/lit)	600 – 3000	2100
TSS (mg/lit)	200 – 1300	100
Alkalinity (Ca CO ₃) (mg/lit)	250 – 350	-
Oil and grease (mg/lit)	300 – 1300	10
Phosphorus (mg/lit)	5 – 10	-
Chlorides (mg/lit)	80 – 100	-
BOD (mg O ₂ /lit)	350 – 1800	30
COD (mg O ₂ /lit)	1100 – 2300	100

Source: Comprehensive Industry Document Dairy Industry, Central Pollution Control Board, Delhi

The BIS has recommended standards for disposal of industrial effluents. These standards of industrial effluents as applicable to dairy wastes are given in Table. No – 24.2.

Table 24.2: BIS Standards for Disposal of Dairy Effluent

Sr. No	Characteristics	Tolerance limits for industrial effluents			
		Into Inland Surface water	Into Public Sewer	On Land for Irrigation	Into Marine Coastal Area
1.	Biochemical Oxygen Demand (5 Days at 20°C) mg/L, Max	30	350	100	100
2.	Chemical Oxygen Demand (mg/L), Max.	250	-	-	250
3.	pH valve	5.5 – 9.0	5.5 – 9.0	5.5 – 9.0	5.5 – 9.0
4.	Dissolved solids (inorganic) (mg/L), Max	2100	2100	2100	-
5.	Suspended solids (mg/L)	100	600	200	a) For process waste water 100. b) For cooling water effluents 10% above total suspended matter of influent cooling water

6.	Temperature (°C), Max.	Shall not exceed 40 in any section of the stream within 15 meters downstream from the effluent outlet	45 at the point of discharge		45 at the point of discharge
7.	Oil and grease, (mg/L), Max.	10	20	10	20
8.	Chloride (as Cl) (mg/L), Max	1000	1000	600	
9.	Boron (as B) (mg/L), Max.	2	2	2	
10.	Sulphate (SO ₄) (mg/L), Max.	1000	1000	1000	
11.	Percent sodium, Max.		60	60	
12.	Ammonical nitrogen (as N) (mg/L), Max.	53	50		50

Quantity and Characteristics of Wastewater

Quantity:

The quantity of waste water generated in the dairy plant depends on various factors such as:

- Total quantity of milk handled per day,
- Products made,
- Processes used,
- Care taken in use of raw water,
- Quantity of water available.

The characteristics of this waste water largely depend on the extent of handling losses of milk encountered as per the operations involved in a dairy plant. Table No – 24.3 shows the milk losses encountered in various operations in a dairy plant.

Table 24.3: Milk Losses Encountered in Some Dairy Operations

Operation	Loss of Milk (Kg/100 kg milk processed)
Milk reception and cleaning	0.1 – 0.6
Chilling raw milk, Storage, washing tanks and pipelines	0.06 – 0.28
Washing tankers	0.09 – 0.36
Separation, storage of SM(Skim milk) and cream and cream pasteurization	0.42 – 1.09
Churning and washing butter	0.23 – 0.73
Evaporation of SM and Drying	0.13 – 1.36
Milk pasteurization and storage	0.09 – 1.49
Cheese making	0.2 – 1.82

The Estimated losses of milk solids for a multi product dairy are given in Tab 24.4

Table 24.4: Estimated Losses of Milk Solids for a Multi Product Dairy

Product mix	Product mix		
	I	II	III
	Standardized Milk and Ghee	Toned Milk and Ghee	Skim Milk Powder and Ghee
Raw Milk			
Quantity (L)	1.0 lakh	1.0 lakh	1.0 lakh
Fat (%)	6.9	6.9	6.9
SNF (%)	9.0	9.0	9.0
Total Fat (kg)	7098.44	7098.44	7098.44
Total SNF (kg)	9258.84	9258.84	9258.84
Total TS (kg)	16357.28	16357.28	16357.28
Quantity of Products			
Skim Milk (kg)	—	—	82154.79
Toned Milk (L)	—	103891	—
Standardized milk (L)	104204.0	—	—
Cream (35 %), kg	6270.88	10881.66	19939.36
Butter (kg)	2706.19	4696.15	8605.13
Ghee (kg)	2139.19	3712.20	6802.19
SMP (expected), kg	—	—	9482.55
SMP (actual), kg	—	—	9470.22
Loss of Milk Solids (%)*			
Fat	1.96	2.58	3.44
SNF	1.58	1.76	2.36
TS	1.75	2.11	2.83

- % Loss on input estimated on the basis of: Processing loss - @ 0.76%; Market milk - @ 0.36% ; Conversion to butter - @ 0.23%; Ghee - @ 2.00%; SMP - @ 0.13%

The parameters of a typical raw and treated effluent have been shown in Table No – 24.5. Similarly, the contribution of various dairy operations to the polluting load of dairy effluent has been compiled in Table No – 24.6, while the BOD & COD values for various dairy products are given in Table No – 24.7.

Table 24.5: Principal Dairy Waste Water Characteristics

Sr.No	Parameters	Untreated	Treated
1	pH	7.5	5.5-9.0
2	Total Dissolved Solids (mg/litre)	1360	<2100
3	Total Suspended Solids (mg/litre)	650	<100
4	BOD (mg/litre)	1200	<30
5	COD (mg/litre)	2000	<100
6	Oil & Grease (mg/litre)	320	<10

Table 24.6: Contribution of BOD Load Through Different Dairy Operations

Operation	Kg BOD/m ³ of milk processed	
	Average	Range
M i r e c e t o n , c a n w a s h i n g , c l e a n i n g u p	0.26	0.11-0.66
Cooling raw milk, storage, washing tanks and pipelines	0.19	0.07 - .31
Washing tanks	0.25	0.10 - .40
S e a r a t i n g , s t o r a g e o f s k i m m i l k a n d c r e a m	0.14	0.09-0.24
T e a b o v e p l u s c r a m p a s t e u n g	0.66	0.46-1.20
C h u g a d w a s h i n g b u t t e r	0.46	0.25-0.30
E v a p o r a t i n g s k i m m i l k o f l o w t o t a l s o l i d s	0.23	0.16-0.30
E v a p o r a t i n g s k i m m i l k o f h i g h t o t a l s o l i d s a n d s p r a y d r y i n g	0.74	0.14-1.50
R o l l e r d r y i n g	0.53	0.25-1.30
P a s t u r i n g m i l k a n d s t o r a g e	0.29	0.10 - .54
B o t t l e p a s t u r i e d m i l k	0.11	—
B o t t l e w a s h i n g	0.23	—
P a s t e u r i n g m i l k , b o t t l i n g a n d b o t t l e w a s h i n g	0.85	0.05-0.37
C l o t e d c e a s e	1.20	0.49-1.70
C r a m p a s t e u r i n g a n d p a c k i n g	0.79	—
C h e s e m a k i n g (h a r d - p r e s s e d)	0.89	0.23-2.00
C o t t a g e c h e e s e (w a s h e d c u r e d)	15.00	—
C o n d e n s i n g f r e s h w h e y t o l o w t o t a l s o l i d s	0.25	—
C o n d e n s i n g s w e e t e n e d s e p a r a t e d c o n d e n s e d m i l k	1.40	1.20-1.70
F u l l c r e a m e v a p o r a t e d m i l k w i t h c a n n i n g	0.75	0.50-1.00

Table 24.7: BOD and COD Values for Various Dairy Products

Product	BOD /litre	COD /litre
Whole M i l k	120000	210000
S k i m m i l k	70000	100000
C r e a m (30% F a t)	400000	860000
B u t t e r M i l k	75000	110000
W e s t e r n M i l k	42000	75000

Management of Dairy Effluent

The dairy effluent management involves use of physical, chemical and biological methods or their combination. The various methods and process options with their function, have been shown in Table No - 24.8. However, the selection of method depends on several criteria including the availability of resources, physicochemical characteristics of effluent, BOD load variation, quantity/volume variation, location of treatment site, regulatory standards and economics of the treatment.

While managing dairy effluent, the chemical as well as biological sludge is generated which needs proper treatment before its disposal. Treatment of sludge prior to disposal

is necessary to aid environment compatibility. The sludge treatment has to be reliable, legally acceptable, economically tolerable and easy to operate.

Table 24.8: Treatment Methods for Dairy Effluent

Method	Process Options	Function
Physical	Screening Fat/scum removal Equalization Neutralization (optional) Separation/Clarification Electrolytic coagulation Ozonization Membrane process	Arrest of solids Reduction of fat Homogenization Maintain pH value Reduction of suspended solids Precipitation Precipitation Separation
Chemical Biological	Coagulation/Flocculation	Precipitation
Aerobic Process	Aerated lagoons Activated sludge Oxidation ditch/Stabilization Ponds Tricking filters Rotating biological discs Biological filter	Bio degradation
Anaerobic Process	Conventional anaerobic Digester Anaerobic contact Digester Anaerobic fixed Film reactor Fluidized bed reactor Up-flow anaerobic Sludge blanket	Bio – degradation

Approaches for Treatment

While designing effluent treatment plant all possible ways should be considered to reduce the waste for which involvement and cooperation of dairy management is essential in a sustained manner.

Waste Reduction:

Waste reduction from dairies can be achieved in several ways such as:

- Providing more time for draining the cans.
- Using a small quantity of water in a fine spray after draining cans and providing further time for draining.
- Preventing spillage of milk or other dairy products.
- Checking joints, packing glands and seals from time to time to prevent leakage.
- Reduction of waste volume by segregation of clean water streams like condensate and cooling water, from the strong wastes.
- Reclamation of waste products, and,
- Byproduct recovery.

Suggested Approach for Effluent Treatment:

The design of treatment plant should be carried out taking into account:

- Pollution control requirement.
- Quantity and characteristics of wastewater generated.
- Availability of land for treatment plant.
- Technical manpower and infrastructure available for operation & maintenance.
- Construction and operation & maintenance cost.

Treatment Capabilities of UASB:

Recent information on technologies for wastewater treatment reveals considerable potential for application of Upflow Anaerobic Sludge Blanket (UASB) Reactors or their modifications for treatment of dairy wastewaters. Fig. No – 24.1 shows Process Flow Diagram for Effluent Treatment Plant based on Upflow Anaerobic Sludge Blanket Process.

Effluent Flow – 200 m³/d

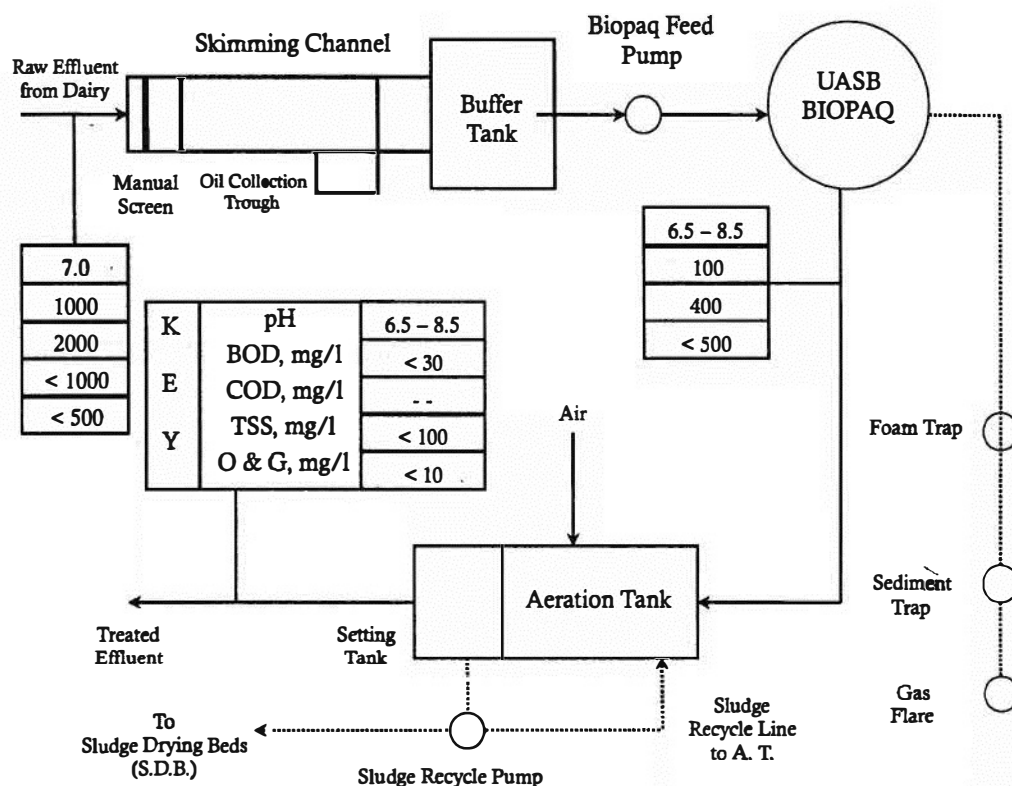


Fig 24.1: Process Flow Diagram for Effluent Treatment Plant based on Upflow Anaerobic Sludge Blanket Process (UASB)

Process Description

The raw effluent from the dairy enters through a screen into the skimming channel where the floating matter comprising oil and grease rises and remains on the surface until removed. The skimmed oil and grease are collected through a slotted pipe into an oil trough which can be disposed off manually. The effluent overflows into a buffer tank where the acidogenesis phase is triggered immediately. The effluent is then pumped into the biopaq reactor through a series of distribution pipes. The multiple distribution ensures a uniform flow of liquid throughout the sludge blanket making maximum use of available high bacterial population. The liquid rises to the top of biopaq reactor along with the biogas generated and also some sludge particles.

A unique three phase separator, separates out the gas, liquid and the sludge particles. The biogas is allowed to leave through collecting domes and is carried through a gas header, foam trap, sediment trap and flame arrestors to gas flare for ultimate flaring to atmosphere. The liquid overflows through the gutters and the suspended solids then separated are allowed to settle down in the sludge blanket thereby retaining valuable bacterial population (attached to the suspended solids).

The anaerobically treated effluent will flow by gravity into an aeration tank which is based on conventional activated sludge process. The aeration tank is designed for a specific organic loading rate, Mixed Liquid Superior Solids concentration (MLSS), Hydraulic Retention Time and sludge return concentration. The aerobic environment in the tank is achieved by means of a mechanical surface aerator which also helps to keep the contents in a mixed regime. The activated sludge is then settled in a settling tank. A portion of settled activated sludge is pumped to the aeration tank to maintain a desired MLSS concentration, while the excess sludge is pumped to sludge drying beds for necessary sludge dewatering.

ADVANTAGES OF ANAEROBIC EFFLUENT TREATMENT OVER CONVENTIONAL METHOD

The Up flow Anaerobic Sludge Blanket (UASB) – Biopaq process has been accepted world over as the most cost effective process due to following:

- a) Higher efficiency and working results.
- b) Compact reactor, hence space reduced to a large extent.
- c) Very low power consumption (mainly required for feed pumps only).
- d) Stable process.
- e) Production of stabilized excess sludge is low with very good dewatering characteristics.
- f) Low nutrients requirement, as bacteria retains Nitrogen & Phosphorus and there is no destruction of cell.

- g) Resistant to shock loading.
- h) Methane rich biogas is produced as a by-product.
- i) Volumetric loading rate is high.
- j) In case of power failure or long shut down, the bacteria go into dormant stage and plant can be restarted to take full load within short period.
- k) Since the anaerobic digestion takes place in a closed reactor, there is no foul smell in surrounding area and in the vicinity of E.T.P. Further, the nuisance due to flies, mosquitoes, etc., is totally eliminated.
- l) "UASB" process eliminates large number of pumps / blowers / aerators, etc., hence operating and maintenance cost reduces to a large extent.

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Chapter 25

Dairy Professional's Ready Reckoners

Cleaning and Sterilizing

The cleaning process in dairies, where the production of foodstuff for human consumption takes place, should be carried out with extreme thoroughness.

The impurities which have to be removed consist of organic constituents such as protein, fat and sugar as well as inorganic salts from milk and water. The impurities can be removed by the use of various acids and alkalis.

The method of cleaning and the cleaning agent used depend upon various factors, but the aim should be to carry out the cleaning process as cheaply and easily as possible without thereby lowering the hygienic standard.

Modern plants are fabricated in stainless steel so that C.I.P. cleaning can be employed.

When choosing the type of cleaning agent and the method of cleaning, it is always necessary to take into account the nature of the dirt and the material of the surface to be cleaned; for instance strong alkalis (sodium hydroxide, tri-sodium phosphate, soda etc.) are harmful to aluminum unless a protecting agent is added such as water glass. The stainless steel used in the dairy industry is resistant to both strong alkalis and most acids, but not to hydrochloric acid or disinfecting mediums containing chlorine, unless the latter has had a protective agent added which is effective against all forms of corrosion.

If the cleaning is carried out manually, the effect of the cleaning agent on the human skin must also be taken into consideration.

Sterilization should only take place after the equipment has been thoroughly cleaned as, especially with thermal sterilization, the effect is considerably reduced if there are still deposits on the surface.

Pasteurizing Plants

Nature of deposits: Burnt-on organic constituents such as protein, fat, lactose, organic salts, etc., and inorganic salts from milk and water.

Material: Stainless steel.

Method of cleaning: C.I.P

When treatment of the milk is over, the pasteurizing plant, consisting of plate heat exchanger, pumps, cocks and pipes, should be thoroughly flushed through with cold water, and then switched over to closed circulation. Through a dosing funnel, add 0.5-1 litre commercial nitric acid (62%) per 100 litres water. This solution should be allowed to circulate for 20-30 minutes at a temperature of appr. 60°C, after which it should be flushed out of the plant with plenty of water. An alkaline cleaning fluid consisting of 300 - 500 gm sodium hydroxide to 100 litres water should then be circulated for the same length of time and at a temperature of appr. 75°C. If the water is very hard, 300gm trisodium phosphate per 100 litres should be added to the solution.

Powdered cleaning agents should first be dissolved in water before being added through the funnel to the circulating water in the plant. Finally, the plant should be very thoroughly rinsed with at least twice the quantity of water that the whole plant can contain.

If the pasteurizing plant is very dirty, for example because milk of bad quality has been pasteurized, it may be necessary to use more concentrated cleaning fluids, or to change the order of use, that is to say the alkaline fluid should be used first; but also under these circumstances should the cleaning fluids be immediately rinsed out with plenty of clean water.

In the morning, before milk processing is started, the pasteurizing plant must be sterilized. This can be done by circulating clean water throughout the plant with open stream cock, until the temperature of the water after the cooling section of the plate heat exchanger is 80-90°C. The water should be allowed to circulate at this temperature for 10 minutes. Chlorine should not be used for sterilizing.

It must be pointed out that it is necessary, when cleaning and sterilizing not to neglect the pipes to, for example, the butter or cheese making sections. If it is not possible to establish a circulation, the fluids must at least be pumped through these pipes. Which should also be sterilized every morning by steam hosing, and they should be frequently inspected.

Butter Churns

Nature of the deposits : Fat and inorganic salts.

Material : Stainless steel.

Method of cleaning : See below.

After removing the butter residue from the churn, cleaning can be carried out in the following manner.

- a. *Normal Cleaning.* The churn should first be washed with hot water at about 95°C. The quantity of water used should be equal to 10% of total churn capacity, and the churn should be set at maximum speed for 5 minutes during each cleaning process.

- b. *Cleaning with turbine.* The cleaning agent used is sprayed on inside the churn by means of a cleaning turbine. The cleaning agent consists of appr. 50 litres water at a temperature of appr. 65°C with an admixture of 0.5% tri-sodium phosphate. The solution is circulated for 5 minutes, after which time the churn is drained and rinsed with clean water. This treatment can be followed by circulating the 0.5% nitric acid (HNO_3) solution in the same way. Normally it is not necessary to circulate acid through the churn every day. Final treatment should consist of sterilization by means of hot water or steam. It is important that the vacuum pipe and churn door are cleaned every day. After sterilization, the door should be left closed and the buttermilk drain valve opened to allow equalization of air pressure. Cleaning in the above ways helps to preserve the water film inside of the churn, thereby preventing adherence of butter to the churn during working.

Dairy Equipment (Transport churns, separator parts, cheese vats, tanks and vats).

Nature of deposits: Organic constituents such as protein, fat, organic salts, etc., and inorganic salts from milk and water.

Material : Aluminium, stainless steel or tinned metal.

Method of cleaning: Manual.

In case where the deposits have dried up, it may be necessary to use quite strong alkali such as soda, trisodium phosphate or sodium metasilicate. To prevent corrosion, it will be necessary to add from 0.1-0.3% water glass to the cleaning solution.

If the dirty surfaces are still wet, a less alkaline cleaning fluid should be used, and it may be possible to use a mild alkali combined with a polyphosphate and/or another detergent (sulpho soap).

The above-mentioned chemicals can of course be replaced by suitable commercial preparations.

From time to time, it will be necessary to remove deposits of milk stone from the above surfaces if sterilization is to be effective. The best removal is achieved by use of weak acid solutions. Stainless steel surfaces are best cleaned by means of a diluted HNO_3 solution or even more effective would be to use one of the organic acids given on page 33 and under no circumstances should other acids be used for tinned and aluminium surfaces.

Sterilization is most effectively achieved by using boiling water, but where this is not practical, steam or chemical sterilization can be used.

The majority of milk and cream tanks are designed so that cleaning can be carried out by means of a cleaning turbine in the same way as mentioned under the section dealing with churns.

Cleaning Agents

Alkaline Cleaning Agents

Sodium hydroxide (NaOH), commonly called caustic soda, is a powerful alkali. Caustic soda is white substance that is mainly sold in flake form. Because of its tendency to absorb moisture from the air, it should be dispatched and stored in tightly closed metal containers. Sodium hydroxide can also be bought in liquid form, in which case it is known as soda lye, but of course such solutions are not as concentrated as the pure caustic soda, which usually contains at least 95% sodium hydroxide.

Sodium hydroxide breaks up and dissolves protein particles, saponifies fats under the prolonged influence of high temperatures, and precipitates the hardness of the water as floccules. It has a strong corrosive effect on aluminium and tin, and it is very harmful to the human skin.

Sodium hydroxide is widely used in connection with C.I.P. cleaning of plants for the heat treatment of milk.

Molecular weight: 40. Specific gravity: 2.13.

Soda can be obtained in two forms, the anhydrous soda (Na_2CO_3) that can be bought under the name soda ash, and washing soda ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$) Which contains 37% Na_2CO_3 . Therefore it takes a good $2\frac{1}{2}$ parts washing soda to replace one part soda ash, which is worth remembering when considering the cost.

Soda, which can be made up into a fairly strong alkaline solution, dissolves protein to some extent, emulsifies fats and precipitates the hardness of the water. It corrodes both aluminium and tin, and it is irritating to the human skin.

Molecular weight	: Soda ash	106.0
„ „	: Washing soda	286.16
Specific gravity	: Soda ash	2.53
„ „	: Washing soda	1.46

Trisodium Phosphate ($\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$), is powerful alkali. It is bought in powder form with somewhat varying water content, but the powder usually sold contains appr. 57 % water. It dissolves protein and is an excellent emulsifying agent for fats, holds dirt particles in suspension and precipitates the hardness of water as floccules. It has a strong corrosive effect on aluminium and tin and is irritating to the human skin. Molecular weight: 380.20. Specific gravity: 1.62.

Sodium Metasilicate ($\text{Na}_2\text{SiO}_3 \cdot 9\text{H}_2\text{O}$) is a fairly powerful alkali, which is sold in powder form. It has the same ability as water glass, although to a lesser degree, to protect

aluminium and tinned surfaces from corrosion. It is therefore frequently used as an ingredient of compound cleaning agents and disinfecting agents containing chlorine. Sodium Metasilicate has only a slightly irritating effect on the human skin. Molecular weight: 284.19.

Polyphosphates is the common name of a number of high molecular phosphates being used as ingredients in compound cleaning agents because of their ability to prevent the formation of tone by forming soluble compounds with calcium and magnesium salts. The most normally used polyphosphate is sodium hexametaphosphate, which, in a solution of water, has a neutral reaction, and practically no harmful effect on metals or human skin.

Acid Cleaning Agents

Nitric acid (HNO_3) is a strong inorganic acid that can easily dissolve milkstone and hard water scale. It attacks tinned metals very strongly but not aluminium or stainless steel. The strongly oxidizing acid has a stabilizing effect upon stainless steel, and also has a good disinfecting effect. It is harmful to the human skin and produces a brown discolouration.

Nitric acid is widely used in connection with C.I.P. cleaning of plants for the heat treatment of milk. For this purpose acid with a strength of 60% is normally used.

Molecular weight : 63.02.

Specific gravity : (60%) approx. 1.37

Phosphoric acid (H_3PO_4) is a medium strong inorganic acid which is used to some extent instead of nitric acid.

Molecular weight : 98.04. Specific gravity : 1.83.

Organic Acids (acetic, oxyacetic, gluconic acid, tartaric acid, citric acid, etc.) have, even in stronger concentration, a relatively high pH, so that their corrosive effect upon metals is very much less than even weak solutions of nitric acid. They have good buffering ability, which makes them useful for removal of milk stone and hard water scale. They are only slightly harmful to human skin.

Wetting Agents

There are three groups of wetting agents, of which two are becoming known in the Dairy industry. The so-called sulfo soaps are being increasingly used for cleaning purposes, while the second group, the quaternary ammonium compounds (see below) are used as disinfecting agents for special purposes.

In a cleaning fluid, they have an emulsifying effect on dirt, which is thereby easier to remove from the surfaces to be cleaned. This has special significance when cleaning greasy surfaces. They are not influenced by pH, and can be used alone or combined with either alkaline or acid cleaning agents. They dissolve easily in cold water, are not influenced by the hardness of the water, and leave surfaces clean and sparkling. They can be used in very low concentrations, for example 0.01%. They have no corroding effect on metal, and are only very slightly harmful to the human skin.

Commercial Cleaning Preparations

For many cleaning purposes (for example membrane filtration plants) a single chemical does not possess all the qualities that are required. It has therefore been the practice to combine two or more chemicals in order to obtain a single product that covers all the qualities desired. The same course of action is used when manufacturing the so-called commercial preparations.

Checking the Concentration of the Sodium Hydroxide and Nitric Acid Solution in Cleaning Plants

The check is carried out by titration of the cleaning solution. 10 ml is measured into a dish or flask to which is added 4 or 5 drops of phenolphthalein. Then while stirring, and using a burette, add drop by drop 0.1 N hydrochloric acid to the sodium hydroxide solution and 0.1 N sodium hydroxide to the nitric acid solution until the colour changes.

The amount of titration fluid used up to the point when the colour changes can be read on the burette, and the table below shows the strength in kg or litres.

Apparatus:

1 × 10ml pipette.

1 × 100ml flask or porcelain dish with glass spatula.

2 × 25ml burette, attached to 1 litre plastic bottles.

The burette to be used for sodium hydroxide should have a filter for the absorption of carbon dioxide in the air.

Reagents:

0.1 N sodium hydroxide NaOH.

0.1 N hydrochloric acid HCl.

5% alcoholic phenolphthalein solution.

Sodium hydroxide NaOH			Nitric acid HNO ₃		
ml 0.1 N hydrochloric acid per 100 ml	% sodium hydroxide NaOH (kg/100 l)	30% fluid sodium hydroxide NaOH (1/100 l)	ml 0.1 N sodium hydroxide NaOH per 100 ml	% nitric acid HNO ₃ (kg/100 l)	62% nitric acid HNO ₃ (kg/100 l)
0.0	0.0	0.0	0.0	0.0	0.0
2.5	0.1	0.25	1.4	0.09	0.1
5.0	0.2	0.50	2.7	0.17	0.2
7.5	0.3	0.75	4.1	0.26	0.3
10.0	0.4	1.00	5.4	0.34	0.4
12.5	0.5	1.25	6.8	0.43	0.5
15.0	0.6	1.50	8.1	0.51	0.6
17.5	0.7	1.75	9.5	0.60	0.7
20.0	0.8	2.00	10.9	0.69	0.8
22.5	0.9	2.25	12.2	0.77	0.9
25.0	1.0	2.50	13.6	0.86	1.0
27.5	1.1	2.75	14.9	0.94	1.1
30.0	1.2	3.00	16.3	1.03	1.2
32.5	1.3	3.25	17.6	1.11	1.3
35.0	1.4	3.50	19.0	1.20	1.4
37.5	1.5	3.75	20.4	1.28	1.5
40.0	1.6	4.00	21.7	1.37	1.6
42.5	1.7	4.25	23.1	1.46	1.7
45.0	1.8	4.50	24.4	1.54	1.8
47.5	1.9	4.75	25.8	1.63	1.9
50.0	2.0	5.00	27.2	1.71	2.0

The table is based on the following formula:

$$\text{Concentration} = \frac{a \times b \times c}{d \times 10} \text{ \% (kg/100L)}$$

a = ml titration fluid until colour changes.

b = normality of titration fluid (0.1).

c = molecular weight (HNO₃ 63.02 – NaOH 40.0).

d = ml cleaning solution (10 ml).

Specific gravity for 62% HNO₃: 1.38 kg/litre.

Specific gravity for 30% NaOH: 1.33 kg/litre.

Nitric acid is normally used in concentrations of 0.5-0.8%, corresponding to pH 1-2.

Sodium hydroxide is used in concentrations of 0.8-1.0 %, corresponding to pH 12-13.

Sterilizing Mediums

Nitric acid (HNO_3) is now being used more and more as a sterilizing agent. An addition of about 0.5 litre of nitric acid (60%) per 100 litres of water is considered adequate.

Chloride of Lime is a white powder, one of the ingredients of which is calcium hypochlorite which can liberate oxygen and therefore amongst other things has a sterilizing effect. The sterilizing effect of chloride of lime is in ratio to its contents of active chlorine. A fresh concentrated solution contains approx. 33% active chlorine. It corrodes aluminium, tin and stainless steel to a certain extent, but if water glass is added, corrosion can be prevented. The human skin is only slightly effected.

Sodium Hypochlorite (NaClO) is an alkaline solution that usually contains 10-15% active chlorine. It has the same corroding effect on aluminium, tin and stainless steel as chloride of lime, but corrosion can be reduced by adding water glass. It has a slightly harmful effect on aluminium, tin and stainless steel as chloride of lime, but corrosion can be reduced by adding water glass. It has a slightly harmful effect on human skin.

Chloramine is organic 25% active chlorine. Compared to chloride of lime it has better keeping qualities, dissolves more easily, is less corrosive and makes a clearer solution. On the other hand, it has the drawback that solids from the chloramines go into the milk. Chloramine has only a slight effect on human skin.

Quaternary Ammonium Compounds are classified under wetting agents, but also have certain bacteria – killing properties that for some of the compounds are as high as those of the chlorine group. Their special wetting properties give them a greater affectivity than chlorine solutions, as they can more easily penetrate crevices in rough surfaces. Unfortunately, these preparations, even when used in very small quantities, have a strongly inhibiting influence on the growth of lactic acid bacteria. Their use in the Dairy industry is therefore limited, even though they are neither corrosive nor harmful to the human skin.

Dairy Effluent

The increase in the size of dairies produces mounting problems with the discharge of the rising quantities of effluent. In addition, new dairies are placed outside city areas where the existence of effluent processing facilities is the exception rather than the rule.

Discharge taxes necessitate the knowledge of both the quantity of effluent as well as the contents of pollutants. The pollutants in dairy effluent are primarily the organic substances fat, protein, and lactose.

Two methods are used to determine the contents of organic material in effluent: BOD and COD.

BOD (Biological Oxygen Demand) is determined by examining the quantity of the soluble oxygen from an aqueous sample by leaving it for 5 days at 20°C. The oxygen quantity is established by letting the dissolved oxygen oxidize iodine into and establish the released quantity of iodine by titration with thiosulphate. The result is expressed in mg oxygen per litre.

COD (Chemical Oxygen Demand) is determined by treating a sample with potassium dichromate solution and neutralize excess dichromate by titration with ferrous ammonium sulphate. This is done simultaneously with a blind test for control of the chemicals. The quantity of dichromate used in the treatment is an expression of the chemical oxygen demand. The result is stated in mg oxygen used for each litre of sample.

The below table states COD values and thus the pollution degree of whole milk, skim milk, and whey.

Substance	Whole milk		Skim Milk		Whey	
	Contents mg/L	mg COD/ kg	Contents mg/L	mg COD/ kg	Contents mg/L	mg COD/ kg
Fat	40,000	120,000	400	1,200	400	1,200
Protein	34,000	46,000	34,000	46,240	10,000	13,600
Lactose	46,000	52,000	47,000	53,110	47,000	53,110
Total		218,000		100,550		67,910

Steam and Energy Requirements for Evaporation and Drying

Data of Falling Film Evaporators with Thermo-Compression

Steam consumption : (Appr.)

<i>Type of Plant</i>	<i>Kg/ Kg evap. water</i>
Triple effect	0.24
Quadruple effect	0.22
Quintuple effect	0.17 – 0.16
Sextuple effect	1.17 – 0.16

Both equipment and technology are completely different from traditional cheese making equipment. However, the obvious advantage of this method is an additional yield of 18 – 20 %.

UNITS OF MEASURE

According to the Metric system

The unit of weight is one kilogram– (kg)

The unit of length is one meter (m).

The unit of time is one second (s).

The unit of temperature is one degree Celsius ($^{\circ}\text{C}$).

The terminal unit is one kilocalorie (kcal).

One kilocalorie (kcal) is equal to the amount of heat required to heat or cool 1 kg water one degree Celsius.

The specific gravity is equal to the weight in grams (gm) of one cubic centimeter (cm^3) of substance.

The unit of work, one kilogram-force metre (kgfm) is equal to the energy required to raise one kilogram to a height of one meter.

The unit of effect, one horse power (hp), is equal to a work performance of 75 kilogramme force metre per second (kgfm/s).

One horse power hour (hph) is equal to the work that can be carried out by one horse power (hp) in one hour.

Specific heat is equal to the number of kilocalories required to heat 1 kg of a substance 1°C .

e.g. water: 1

iron : 0.114

copper : 0.09

air : 0.24

The latent heat of fusion is equal to the number of kilocalories required to change 1 kg of solid substance to liquid when it has previously been heated to melting point.

The thermal conductivity coefficient is equal to the number of kilocalories that are transmitted in one hour through a 1 m^2 cross section of a 1 m thick plate when the temperature difference is 1°C .

The latent heat of evaporation is equal to the number of kilocalories necessary to change 1 kg of liquid to vapour of the same temperature.

The degree of humidity, relative humidity, is equal to the relation between the actual water vapour content of the air, and the amount of water vapour the air can hold at the temperature in question.

The absolute humidity is equal to the weight in grams of the water vapour contained in 1 cubic meter of air.

The dew point is equal to the temperature reached when air is cooled to saturation point.

The unit current intensity, one ampere (A), is equal to a current which, when passed

through a solution of nitrate of silver, is capable of depositing silver at the rate of 1.118 milligrams per second.

The unit of resistance one ohm (Ω), is equal to the resistance in a column of mercury, 106.3 cm long and with a cross section of 1 mm², at a temperature of 0°C.

The unit of potential, one volt (V), is equal to the difference in electrical potential between two separate points on a conductor with a resistance of 1 ohm, and where the electric current is one ampere.

The unit of power, one watt (W), is equal to the energy produced when the strength of the electric current is 1 ampere and the potential difference 1 volt.

The unit of electric energy, one kilowatthour (kWh) is equal to the energy that is (produced or used) by 1 kilowatt (kW) working for 1 hour (h).

Conversion Table

Power and heat flow rate

	hp	Kgfm/s	W	kcal/h
hp*	1	75	736	632
kgfm/s	1.33×10^{-2}	1	9.81	8.43
W	1.36×10^{-3}	0.102	1	0.860
kcal/h	1.58×10^{-3}	0.119	1.16	1

Energy, work and quantity of heat.

	hph	Kgfm	kWh	kcal
hph	1	2.70×10^{-6}	0.736	632
kgfm	3.70×10^{-6}	1	2.72×10^{-6}	2.34×10^{-3}
kWh	1.36	0.367×10^{-6}	1	860
kcal	1.58×10^{-3}	427	1.16×10^{-3}	1

* metric

SI Unit System

SI (abbreviation for System International d'Unites) is a metric system of international units which lends itself to simplification and systemization. The SI system is gaining popularity throughout the world and forms the basis of the first truly international system of measurement. Such units as meter, kilogram, litre, etc. will eventually be used worldwide. There is a definite advantage in applying the same units for all sizes, irrespective of the area measured. For example, the unit of power (Watt) can be used for electric motors and combustion engines. Horse power will gradually disappear from the language. Thanks to uniformity and systemization, no conversion factors

will be required under the SI unit system.

SI includes a range of basic units, derivatives, multiples and sub-multiples. There are also supplementary units, primarily associated with subdivision of the 24-hour day.

Basic SI units:

Length(m) meter
 Mass(k) kilogram
 Timesecond
 Electric current(A) ampere
 Temperature(K) Kelvin
 Luminous intensity(cd) candela
 Amount of substance (mol) mol

Supplementary units:

Plane angle(rad) radian
 Solid angle(sr) steradian

Table showing conversion factors between SI units and other common unit systems.

Example showing use as pressure / stress table:

1450 p.s.i. converted to bar ?

Find factor for the bar, line p.s.i. = 1

$6.9 \times 10^{-2} \times 1450 \sim 100$ bar

Length

SI-unit m	Other units			
	In (inch)	Ft (foot)	Yd (yard)	mile
2.45.10 ²	39.4	3.28	1.09	0.621. 10 ⁻³
0.305	1	8.33.10 ²	2.77.10 ⁻²	15.8. 10 ⁻⁶
0.914	12	1	0.333	0.189. 10 ⁻³
1.161.10 ³	36	3	1	0.568. 10 ⁻³
	63.4.10 ³	5.28.10 ³	1.76. 10 ³	1

Area

SI-unit M²	Other units		
	in² (sq in)	ft² (sq ft)	yd² (sq yd)
1	1.55.10 ³	10.8	1.20
0.645.10 ⁻³	1	6.94.10 ⁻³	0.772.10 ⁻³
9.29.10 ⁻²	144	1	0.111
0.836	1.30.10 ³	9	1

Volume

SI-unit M³	Other units				
	in³ (cu in)	ft³ (cu ft)	yd³ (cu yd)	gallon (UK)	gallon (US)
1	61.0.10 ³	35.3	1.31	220	264
16.4.10 ⁻⁶	1	0.579.10 ⁻³	0.214.10 ⁻⁶	3.60.10 ⁻³	4.33.10 ⁻³
2.83.10 ⁻²	1.73.10 ³	1	3.70.10 ⁻²	6.23	7.48
0.765	46.7.10 ³	27	1	168	202
4.55.10 ⁻³	277	0.161	5.95.10 ⁻³	1	1.20
3.79.10 ⁻³	231	0.134	4.95.10 ⁻³	0.833	1

Velocity

SI-unit m/s	Other units		
	km/h	f/s	mile/h
1	3.6	3.28	2.24
0.278	1	0.911	0.621
9.305	1.10	1	0.682
0.447	1.61	1.47	1

Density (mass / volume)

SI-unit Kg/m³	Other units		
	g/cm³, g/ml	lb/in³	lb/ft³
1	10 ³	36.1.10 ⁻⁶	6.24.10 ⁻²
10 ³	1	3.61.10 ⁻²	62.4
27.7.10 ³	27.7	1	1.73.10 ³
16.0	1.60.10 ⁻²	5.79.10 ⁻³	1

Mass

SI-unit kg	Other units	
	metric tech unit of mass	lb (pound)
1	0.102	2.21
9,81	1	21.7
0,454	4.63.10 ⁻²	1

Force, weight

SI-unit N	Other units	
	kp	lbf (pound force)
1	0.102	0.225
9.81	1	2.21
4.45	0.454	1

Moment of Force

SI-unit Nm	Other units	
	kpm	lbf ft
1	0.102	0.738
9.81	1	7.23
1.36	0.138	1

Pressure, Stress

SI-unit N/m ² Pa (pascal)	Other units				
	bar	Kp/cm ² , at (tec.atmosph.)	mmH ₂ O	mmHg torr	lbf/in ² p.s.i
1	10 ⁻⁵	10.2 · 10 ⁻⁶	0.102	7.50 · 10 ³	0.145 · 10 ³
10 ⁵	1	1.02	10.2 · 10 ³	750	14.5
98.1 · 10 ³	0.981	1	10 · 10 ³	736	14.2
9.81	98.1 · 10 ⁻⁶	0.1 · 10 ⁻³	1	7.36 · 10 ⁻²	1.42 · 10 ⁻³
133	1.33 · 10 ⁻³	1.36 · 10 ⁻³	13.6	1	1.93 · 10 ⁻²
6.90 · 10 ³	6.90 · 10 ⁻²	7.03 · 10 ⁻²	703	51.7	1

Normal atmosphere (atm), 1 atm = 101325 N/m²

Energy, work, quantity of heat

SI-unit J, Nm, Ws	Other units				
	kWh	kpm	kcal	Btu (Bri. thermal unit)	ft. lbf (foot pound- force)
1	0.278 · 10 ⁻⁶	0.102	0.293 · 10 ⁻³	0.948 · 10 ⁻³	0.738
3.6 · 10 ⁶	1	0.367 · 10 ⁶	860	3.41 · 10 ³	2.66 · 10 ⁶
9.81	2.72 · 10 ⁻⁶	1	2.34 · 10 ⁻³	929 · 10 ⁻³	7.23
4.19 · 10 ³	1.16 · 10 ⁻³	427	1	3.97	3.09 · 10 ³
1.06 · 10 ³	0.293 · 10 ⁻³	108	0.252	1	779
1.36	0.377 · 10 ⁻⁶	0.138	0.324 · 10 ⁻³	1.29 · 10 ⁻³	1

Normal atmosphere (atm), 1 atm = 101325 N/m²

Power and heat flow rate

SI-unit W, Nm/s, J/s	Other units				
	Kpm/s	Kcal/h	Btu/h	hp (Bri. horsepower)	hk (metr.horsepower)
1	0.102	0.860	3.41	$1.34 \cdot 10^{-3}$	$1.36 \cdot 10^{-3}$
9.81	1	8.43	33.5	$1.32 \cdot 10^{-2}$	$1.33 \cdot 10^{-2}$
1.16	0.119	1	3.97	$1.56 \cdot 10^{-3}$	$1.58 \cdot 10^{-3}$
0.293	$2.99 \cdot 10^{-2}$	0.252	1	$0.393 \cdot 10^{-3}$	$0.399 \cdot 10^{-3}$
746	76.0	641	$2.55 \cdot 10^3$	1	1.01
7.36	75	632	$2.51 \cdot 10^3$	0.986	1

Input and Output of Electric Motors**Alternating current**

	1 phase	3 phase
Current input (kw) =	$\frac{U \times I \times \cos}{1000}$	$\frac{3 \times U \times I \times \cos}{10000}$
Mechanical output (hp) =	$\frac{U \times I \times \cos}{736}$	$\frac{3 \times U \times I \times \cos}{736}$

U = voltage ; for three phase networks,

U represents tension between two phases.

I = Amperage.

Cos ϕ : See next page table

η : See next page table

$\sqrt{3} = 1.73$

kW, hp and Full- load Current for 3 x 380 volt, 50 cycle Electric Motors, and Approximate Values of cos ϕ and η (at 1500 rpm)

kW	hp	Full-load current amp	cos ϕ	η
0.37	0.5	1.0	0.73	70.5
0.55	0.75	1.45	0.75	71.0
0.75	1.0	1.85	0.78	72.0
1.1	1.5	2.6	0.82	77.0
1.5	2.0	3.4	0.83	78.0
2.2	3.0	4.9	0.83	78.0
3.0	4.0	6.3	0.84	79.0
3.7	5.0	7.8	0.84	80.0
4.0	5.5	9.0	0.84	82.0
5.5	7.5	11.5	0.84	84.0

kW	hp	Full-load current amp	cos ϕ	η
7.5	10.0	15.0	0.85	86.0
11.0	15.0	22.0	0.86	87.0
15.0	20.0	29.0	0.86	88.0
18.5	25.0	36.0	0.87	89.0
22.0	30.0	42.0	0.88	90.0
30.0	40.0	56.0	0.90	91.0
37.0	50.0	69.0	0.86	92.0
45.0	60.0	83.0	0.87	92.0
55.0	75.0	104.0	0.87	92.0
75.0	100.0	136.0	0.87	92.0

Comparison of Boilers using various Fuels.

Sr. No.	Description	Description	Boiler 1	Boiler 2	Boiler 3	Boiler 4
1	Capacity	Kgs/Hr	3000	3000	3000	3000
2	Safety Valve Set Pressure	Kg/Cm ²	17.5	17.5	17.5	17.5
3	Fuel Type		Bagasse	Coal	Husk	Wood
4	Fuel Consumption/hr	Kg/Hr	845	462	688	713
5	Fuel Consumption/day	Kgs per day	20280	11088	16512	17112
6	Fuel Consumption/month	Kgs per month	608400	332640	495360	513360
7	Fuel Cost/month	Rs	2129400	1829520	1981440	1540080
8	Power Consumption/hr	KW	27	19	23	27
9	Power Consumption/day	KW	648	456	552	648
10	Power Consumption/month	KW	19440	13680	16560	19440
11	Power Cost/month	Rs	106920	75240	91080	106920
12	Manpower cost/month	Rs.	7000	7000	7000	7000
a	Fireman Salary	Rs.	4000	4000	4000	4000
b	Helper Salary	Rs.	3000	3000	3000	3000
13	Total Manpower Cost	Rs.	14000	14000	14000	14000
14	Total Cost	Rs.	2250320	1918760	2086520	1661000

Calculation Basis :

FUEL Bagasse Rs. 3.5/- per Kg

Coal Rs. 5.5/- Kg

Husk Rs. 4/- Kg

Wood Rs.3/- Kg

Power Cost Rs.5.5/- Per KW

Calorific Value – GCV 2700 Kcal/Kg

Calorific Value – GCV 4500 Kcal/Kg

Calorific Value – GCV 4500 Kcal/Kg

Calorific Value – GCV 4500 Kcal/Kg

Saturated Steam Table

Absolute pressure Atmos.	Temperature °C	Enthalpy kg⁰	Absolute pressure Atmos.	Temperature °C	Enthalpy kg⁰
0.1	45.45	617.0	2.5	126.79	648.3
0.2	59.67	623.1	3.0	132.88	650.3
0.3	68.68	626.8	3.5	138.19	651.9
0.4	75.42	629.5	4.0	142.92	653.4
0.5	80.86	631.6	4.5	147.20	654.7
0.6	85.45	633.4	5.0	151.11	655.8
0.7	89.45	634.9	5.5	154.72	656.5
0.8	92.99	636.2	6.0	158.08	657.8
0.9	96.18	637.4	6.5	161.21	658.7
1.0	99.09	638.5	7.0	164.17	659.4
1.1	101.76	639.4	7.5	166.97	660.1
1.2	104.25	640.3	8.0	169.61	660.8
1.3	106.56	641.2	8.5	172.13	661.4
1.4	108.74	642.0	9.0	174.53	662.0
1.5	110.79	642.8	9.5	176.83	662.5
1.6	112.73	643.5	10.0	179.04	663.0
1.7	114.57	644.1	12.5	188.92	665.1
1.8	116.33	644.7	15.0	197.36	666.6
1.9	118.01	645.3	17.5	204.76	667.7
2.0	119.62	645.8	20.0	211.38	668.5

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Chapter 26

Dairy Calculations and Formulations

1. Calculation of Total Solids in Milk

From the knowledge of the density or Specific Gravity measured by lactometer reading and the Fat percentage, the Total Solids in milk could be calculated using one of the formulae given below. The formulae give total solids very near the gravimetric results provided properly calibrated instruments are used and the methods recommended for determinations are followed. The formulae could be used for milk with sp. gr. varying from 1.020 to 1.036, and fat percentage upto 10 percent. It has been found that an error of:

0.2 unit in a lactometer reading, changes total solids (TS) by 0.05 percent;

0.1 percent in fat results in a change of 0.13 percent in TS: whereas 1°F. difference in noting the temperature of milk, results in a change of 0.05 percent in TS.

a) For Density Hydrometer/ Lactometer (IS : 1183)

$$TS = 0.25 D + 1.21F + 0.72,$$

Where,

D = (hydrometer reading corrected to 20°C. -1) X 1000

F = Percentage by weight of fat

b) For Specific Gravity Hydrometer/Lactometer

$$TS = 0.25 G + 1.2 F + 0.14,$$

Where,

G = (hydrometer reading corrected to 15.5°C. -1) X 1000

c) For Specific Gravity Hydrometer/ Lactometer graduated at 38.9°C-

$$TS = 1.33F + \frac{273L}{L + 1000} - 0.40$$

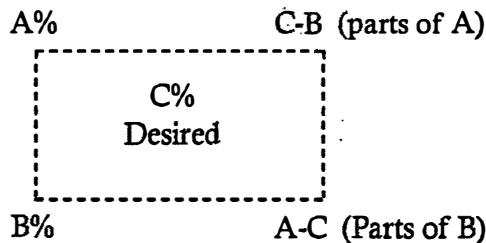
where,

L = Lactometer reading at (38.9°C)

2. Standardizing Milk

Using Pearson Square or rectangle the amount of milk, cream and skim milk to be used in standardizing can be accurately and quickly calculated. The method can also be applied to a wide range of other blending calculations.

A square or rectangle is drawn, and at the upper left hand corner is placed the percentage of fat in the cream to be reduced in fat content, and at the lower left hand corner the percentage of fat in milk to be used for reducing fat in cream. In the centre is placed the percentage of fat desired in the standardised product. The figure in the centre of the square is subtracted from that at the upper left hand corner and the result placed in the lower right hand corner (diagonal), this being the number of parts of milk to be used in the standardising. The percent of fat in milk used is similarly subtracted from the figure in the centre and the result is placed at the upper right hand corner, this figure being the number of parts of cream to be used. The figure at the top right hand corner and lower right hand are added together and divided into the total number of parts needed to find what one part equals. The figure corresponding to one part is then multiplied in turn by each of these two figures to give the number of parts of cream and of milk to use in securing the standardized milk.



Add $(C-B) + (A-C) = \text{total containing } C\%$

The Pearson's Square can be used for standardising a variety of items like ice-cream mixes, adjustment of water content in butter after first churning, hypochloride solution for available chlorine content, mixing water at different temperatures to give water at desired temperature, etc.

3. Determination of Holding Time of HTST Pasteurizer

The holding time for milk for plate pasteurizer is computed by the following formula. The results should be computed separately for forward and diverted flows:

Delivery for holding time for milk (by volume)

$$= T \times M_v / W_v;$$

Delivery for holding time for milk (by weight)

$$= 1.032T \times M_w / W_w;$$

Where,

T = average holding time for water.

Mv = average time required to deliver measured volume of milk.

Wv = average time required to deliver an equal volume of water.

Mw = average time required to deliver a weighed quantity of milk.

Ww = average time required to deliver an equal weight of water.

4. N/10 NaOH Corresponding to Different Percentage of Acidity in Milk

Acidity in milk can be judged by mixing 20 ml. milk containing phenolphthalein indicator and noting the pink colour discharged with addition of N/10 NaOH in ml.

ml N/10 NaOH Solution (20 ml. milk)	% Lactic Acid Upto
2.20	0.10
2.40	0.11
2.70	0.12
2.90	0.13
3.10	0.14
3.30	0.15
3.50	0.16
3.70	0.17
4.00	0.18
4.20	0.19
4.40	0.20
4.70	0.21
4.90	0.22
5.10	0.23
5.30	0.24
5.50	0.25

5. Weight of Milk and Cream of Different Compositions

Fat %	S.N.F %	Total Solids %	Ratio Fat: SNF	Fat % of Total Solids	Sp. gr. 68°F	Weight		
						lb. per USA gal.	lb. per Imperial gal.	kg. per litre
3.0	8.33	11.33	2.77	25.20	1.034	8.61	10.33	1.03
3.1	8.40	11.50	2.71	26.95				
3.2	8.46	11.66	2.64	27.47				
3.3	8.52	11.82	2.58	27.93				
3.4	8.55	11.95	2.52	26.41				
3.5	8.60	12.10	2.46	28.90	1.033	8.60	10.31	1.03
3.6	8.65	12.25	2.40	29.40				
3.7	8.69	12.39	2.35	29.85				
3.8	8.72	12.52	2.30	30.30				

3.9	8.76	12.66	2.25	30.77				
4.0	8.79	12.79	2.20	31.25	1.032	8.58	10.29	1.03
4.1	8.82	12.92	2.15	31.74				
4.2	8.86	13.06	2.11	32.15				
4.3	8.89	13.19	2.07	32.57				
4.4	8.92	13.32	2.03	33.00				
4.5	8.95	13.45	1.99	33.44	1.032	8.58	10.29	1.03
4.6	8.98	13.58	1.95	33.90				
4.7	9.01	13.71	1.92	34.25				
4.8	9.04	13.84	1.88	34.72				
4.9	9.07	13.97	1.85	35.09				
5.0	9.10	14.10	1.82	35.46	1.031	8.58	10.29	1.03
18.0	7.31	25.31	0.41	71.11	1.015	8.48	10.17	1.02
20.0	7.13	27.13	0.36	73.71	1.013	8.43	10.11	1.01
22.0	6.95	28.95	0.31	75.30	1.011	8.42	10.10	1.01
25.0	6.68	31.68	0.27	78.91	1.008	8.37	10.04	1.00
30.0	6.24	36.24	0.21	82.78	1.004	8.36	10.03	1.00
35.0	5.79	40.79	0.16	85.81	1.000	8.32	9.98	0.99
40.0	5.35	45.35	0.13	88.20	0.995	8.28	9.93	0.99
45.0	4.90	49.90	0.09	90.11	0.985	8.22	9.86	0.98

6. Toned, Double-Toned and Reconstituted Milk

FSSAI Rule A.11.01.07 stipulates that recombined milk be prepared from milk fat, non-fat milk solids and water. Non-fat milk solids will include buttermilk powder prepared from sweet-cream buttermilk. Buttermilk powder has a high content of phospholipids like lecithin which have valuable whipping and emulsifying properties. The average composition of buttermilk powder is - moisture 3.5%, milk fat 9.0%, proteins 35.0%, lactose 43.5%, ash 8.0%, minor constituent 1.0%. By using buttermilk powder, especially in the manufacture of recombined milk, addition of emulsifiers and stabilizers, extantaneous to milk, is obviated. When buttermilk powder is not available, a part of the milk solids could be supplied through the use of whole milk containing natural emulsifiers.

The amount of various ingredients to be used in preparing toned and double-toned milk will depend on the composition of milk used as the base. Assuming that milk contains 7.0% fat and 9.0% S.N. 100 kg. or litres of toned milk may be prepared by following the steps indicated:

- All the calculations should be on weight basis as S.M. and butterfat used for the preparation are measured by weight only.
- Assuming the sp. gr. of milk to be 1.030, then 100 litres of milk will weigh 103 kg.
- Requirement of Milk : 100 kg. of toned milk should contain 3.00 kg. fat. Thus, 103 kg. of toned milk will contain 3.09 kg. butterfat.

- d) 7 kg. of fat is obtained from milk used, and so 3.09 kg. from 44.14 kg. This means 44.14 kg. of milk is required for the preparation of 100 litres of toned milk.
- e) Requirement of SMP: 100 kg. of toned milk contains 8.5 kg. SNF, and 103 kg. will contain 8.755 kg. SNF. Out of 8.755 kg. of SNF, a part is contributed by milk. 44.14 kg. of milk will contribute 3.973 kg. SNF. The balance of SNF ($8.755 - 3.973 = 4.782$) will be supplemented from SMP. As SMP contains 4% moisture, the actual amount required is $4.782 \times 100/96 = 4.98$ kg.
- f) Requirement of Water : 100 kg. toned milk contains 88.5 kg. of water, and 103 kg. will contain 91.155 kg. 44.14 kg. of milk used will contain 37.0776 kg. water. The amount of water required will be $91.155 - 37.078 = 54.077$ kg.

The formula for preparing toned milk thus, works out to:

44.14 kg. milk	43 litres of milk
54.08 kg. water or	54 litres water
4.98 kg. SMP	5 kg. S.M.

Requirement for preparing double-toned milk can also be worked out on similar lines.

Formula for recombined milk is derived keeping in mind that in approximate terms, anhydrous milkfat (butter oil) contains 100% fat and no non-fat milk solids or water; S.M. contains 1% fat, 4% water, and 95% non-fat milk solids; Buttermilk powder contains 8% fat, 88% non-fat milk solids and 4% water.

On this basis, recombined milk with 3.5% milkfat and 9% non-fat milk solids is obtained from:

Skim Milk Powder	8.7 kg.
Butter Oil	3.4 kg.
Buttermilk Powder	0.9 kg.
Water	87.0 kg.
	<u>100 kg.</u>

After the preparation of each batch, the composition should be estimated with regard to fat and SNF percent. When taking the specific gravity or density reading, care should be taken that the entrapped air does not give a false reading. The sample should be warmed to $42^{\circ} - 45^{\circ} \text{C}$ for 5 min., cooled to the temperature of determination, and then the lactometer reading should be taken.

The equipment required for preparing recombined milk will depend on the volume to be processed. When small quantities are involved, a batch system of pasteurization and cooling subsequent to recombining will be adequate. When large quantities are

anticipated it will be preferable to install a continuous system of heat treatment and cooling. Whether the batch system or the continuous system is chosen, the equipment will include units for:

Weighing the ingredients,

Mixing and dissolving the milk powders and other ingredients,

Homogenising, filtering and pasteurising the milk,

Cooling and filling in bottles or cartons,

Bottle washing and filling unit,

Cold room for the filled bottles or cartons until sold.

Mixing of the ingredients is done by placing the required amount of water in a jacketed vat fitted with an agitator. The water should be heated to 43.5°C to 49°C and the powder added steadily, agitation being maintained until solution is complete. When the powder has dissolved the resultant solution should be allowed to stand for 20 minutes with the agitators switched off. At the end of this time the agitator is re-started and the milk-fat, previously rendered liquid by being held at 38°–43.5°C in a warm room overnight, is then added and the temperature of the mixture raised to 54.5°–65.5°C for homogenisation and pasteurisation. Homogenisation should be carried out at 54.4°–65.5°C and at a pressure in the homogeniser of around 2,500–3,000 lb. per sq. inch. For smaller installation a viscoliser can sometimes be used in place of the homogeniser. Pasteurization is carried out either by the holding or the HTST method. Recombined milk can also be sterilised, reducing refrigerated storage. Aseptic packaging in non-returnable containers is another alternative.

7. Regenerating Effect of Pasteurizer

The Regeneration Efficiency (RE) is defined as the ratio of the amount of heat supplied by regeneration to the total heat load assuming no regeneration.

Where,

w = mass flow rate 1000 LPH

c = specific heat ; 0.93

θ_1 = inlet temperature (°C) 10°C

θ_2 = temperature leaving regeneration 68.9° C

θ_3 = pasteurisation temperature 80°C

If milk enters at 10°C, it will leave the regeneration section (having 95% RE) at 68.9°C. If it is assumed that there is no heat loss over the regeneration section, then $(\theta_2 - \theta_1) = (\theta_3 - \theta_4)$ i. e., the cooled milk will leave the regeneration section at a temperature (θ_4) of 13.1°C. The product is then cooled from 13.1°C to below 10°C in the chilling section.

$$= \frac{1000 \times 0.93 (68.9 - 10)}{1000 \times 0.93 (80 - 10)} \times \frac{58.9}{70} = 84\%$$

8. Standardization of Milk and Milk Products for Manufacture

Before the manufacture of products like milk powder, condensed milk, evaporated milk, cheese and other products; the fat: S.N.F. ratio in the milk must be adjusted to a figure depending on the desired composition of the product. Fat and total solids content of milk must be first determined. If the fat : S.N.F. ratio is low, it will be necessary to add cream. Generally, cream containing 40% fat is used. If the fat: S.N.F. ratio is too high, skim milk must be added. After the additions of cream or skim milk, the product must be checked. The adjustment can be conveniently done using the formulae:

If cream is to be added $C = (S_1 \times R) - F_1 / F_2 - (S_2 \times R) \times M$;

If skim milk is to be added $X = (F_1 / R) - S_1 / S_3 - (F_2 / R) \times M$,

Where,

C = amount of cream to be added,

X = amount of skim milk to be added,

M = milk in the batch,

R = ratio of fat : S.N.F. required,

F₁ = fat % in milk,

F₂ = fat % in cream,

F₃ = fat % in skim milk,

S₁ = S.N.F. % in milk,

S₂ = S.N.F. % in cream [may be taken as 0.09 (100 - F₂)],

S₃ = S.N.F. % in skim milk.

Cream

Approximate S.N.F. % in cream = $(100 - F) / 11$

Weight of skim milk from 100 parts of milk = $\frac{F_2 - F_1 \times 100}{F_2 - F_3}$

Weight of fat lost in skim milk = Weight of skim milk $\times F_3 / 100$

$$\text{Weight of Fat to be added} = \frac{F - F_1}{F - F_3} \times \frac{F_3}{F_1} \times 100$$

When cream contains higher fat content than required, it could be standardised by adding thinner cream, milk or skim milk according to the formula:

$$\text{Amount to be added} = \frac{\text{Kg. cream} \times (F_2 - \text{Desired Fat \%})}{\text{Desired Fat \%} - \text{Fat \% of standardising material}}$$

When cream is to be standardised to a desired fat percent without increasing the amount, the amount of cream to be replaced by the standardising material is calculated as:

$$\text{Quantity of cream} \times (F_2 - \text{Desired fat \%}) = F_2 - \text{Fat \% of standardising material}$$

Butter

Maximum overrun of butter with 80% minimum butterfat = $100/80 \times 100 = 125$;

Or allowing for 1 unit margin in butter fat content = $100/81 \times 100 = 123.5$.

Weight of water to be added to make up water in finished

$$\text{Butter} = \frac{\text{Desired moisture (\%)} - \text{Actual moisture test (\%)}}{\text{Water - free solids in 100 parts of unfinished butter} \times \text{Load of butter in churning}}$$

$$\text{Yield of butter from milk} = \frac{M \times (F_1 - \text{Loss of fat in separation and churning})}{\% \text{ fat in butter}}$$

$$\text{Or (approx)} = \frac{M - (F_1 - 0.1)}{82.5}$$

$$\text{Yield of butter from cream} = \text{Quantity of Cream} \times F_2 / 84$$

Churning efficiency (i.e., the amount of fat left in buttermilk expressed as a percentage of the total fat in cream before churning)

Equals

$$\frac{(100 - 1.17 F_2) \times \text{Fat \% in buttermilk}}{F_2}$$

Calculating the percentage of fat churned lost in butter :

Fat % in Cream Factor X Fat % in buttermilk

23.0 3.15 X ,,

25.0 2.80 X ,,

30.0 2.13 X ,,

35.0 1.66 X ,,

40.0 1.30 X ,,

44.5 1.05 X ,,

Ice Cream

The protein percent in Ice cream can be determined by formal titration as,

$$(\text{ml} \times N \times 9.04) - 0.14,$$

Where,

ml = net ml. of NaOH for formal titration per 100 g.

N = normality of NaOH used.

Condensed Milk

Relation Between Concentration of Milk Density/Baume

Concentrated milk generally emerges from the evaporator at a temperature of 48.9° C. The relationship between concentration and degree Baume and density at this temperature is given in the next table.

Density	° Baume	% Total Solids in Unsweetened Condensed Milk (26% fat)	% Total Solids in Unsweetened Condensed Skim Milk
1.043	5	21.0	
1.050	7	23.8	
1.058	8	26.5	17.4
1.065	9	29.1	19.2
1.073	10	32.0	21.1
1.081	11	34.8	22.9
1.090	12	37.6	24.7
1.098	13	40.4	26.5
1.106	14	43.2	29.2
1.114	15	46.0	30.0
1.122	16	48.7	31.8
1.131	17		33.5
1.141	18		35.2
1.150	19		37.0
1.160	20		38.7

1.169	21		40.5
1.179	22		42.3
1.188	23		44.1
1.198	24		45.9
1.208	25		47.7
1.218	26		49.5
1.228	27		51.3

(For densities above 1.00, °Baume=145– (145/density)

When the temperature of the concentrate is higher or lower, an adjustment could be made to correct the reading to 120° F. For each degree F above 120° F, add 0.032° Baume to the observed reading, for each degree below 120° F, subtract 0.032° Baume.

Total solids could also be calculated by the refractometer method – T.S.=0.9041 R–0.05, where R is the corrected reading at 20° C. (for each degree above 20° C., subtract 0.077 per degree C).

Cheese

The yield of cheese from milk is influenced by many factors such as the fat percent and protein percent of the milk, the moisture percent of the cheese, as well as the amount of fat, protein, lactose and ash retained in the cheese. An example of how to calculate the yield of ripened cheese from 100 kg cheese milk when 45% fat in solids is required is given below.

Fat percent whole milk	4.2
Protein percent whole milk	3.4
Fat percent cheese milk	3.0
Retention figure for fat	90
- protein	75
- lactose	3
- ash	35
Moisture content of cheese%	42

Calculation

Fat

$$\frac{3.0 \times 90}{100} = 2.70 \text{ kg}$$

Protein

$$\frac{3.4 \times 75}{100} = 2.55 \text{ kg}$$

Lactose

$$\frac{4.7 \times 3}{100} = 0.14 \text{ kg}$$

Ash

$$\frac{0.8 \times 35}{100} = 0.28 \text{ kg}$$

Total Dry Matter 5.67 kg

$$\text{Kg. ripened cheese} : \frac{5.67 \times 100}{58 - \text{NaCl} (\sim 2\%)} = 10.1 \text{ kg}$$

9. Relation of Baume to Total Solids in Sweetened Condensed Skim milk (assuming a sucrose-in-water ratio of approx. 62%)

Baume at 120° F/48.9° C	Density	Sucrose	Serum Solids %	Total Solids %
37.4	1.342	45.63	27	72.63
37.6	1.345	45.00	28	73.00
37.8	1.347	44.38	29	73.38
38.0	1.349	43.75	30	73.75
38.2	1.352	43.13	31	74.13
38.4	1.354	42.50	32	74.50

10. Dairy Professional's Ready Reckoners

Approximate Milk Equivalent of Milk Products

Product	Kg Product per 100 kg Milk		Kg Milk Required for 1 kg Product	
	Buffalo Milk 6% Fat + 9% SNF	Cow Milk 4% Fat + 8.5% SNF	Buffalo Milk	Cow Milk
Skim milk	85.2	90.2	1.2	1.1
Butter milk	7.6	5.1	13.2	19.6
Cream, 40% fat	14.8	9.8	6.8	10.2
Butter	7.2	4.7	13.9	21.0
Ghee	5.7	3.8	17.5	26.3
Dahi	91.0	77.0	1.1	1.3
Chhana	21.7	20.0	4.1	5.0
Khoa	30.0	18.0	4.6	5.6
Conc. Milk, 50% TS	9.5*	25.0	3.3	4.0
Skim milk powder	15.5	9.0*	10.5*	11.0*
Full cream powder	13.6	12.9	6.5	7.8
Cheese, cheddar	6.9*	10.4	7.4	9.6
Cheese, cottage	7.5*	6.8*	14.8**	16.1**
Casein raw	86.4	89.6	13.6**	14.8**
Whev			1.2	1.1

*kg per 100 kg of skim milk **kg skim milk required

11. Equivalents and Conversion Ratios of Milk to Products

100 kg. of milk 3.8% fat approx. yield 40 kg. condensed milk ;

To yield 1 kg Product	Equivalents of Milk (litres)			Conversion for Standardized Milk
	Cow Milk (fat 3.5% SNF 8.5%)	Buffalo Milk (fat 6.0% SNF 9.0%)	Standardized (fat 5.5% SNF 9.0%)	
Cream	11.4	9.2	10.2	9.8
Malai	7.1	4.2	4.6	20 to 25
Butter	22.8	13.4	14.5	6.9
Ghee	28.7	16.7	18.1	5.5
Dahi	1.4	1.1	1.2	86.2
Chhanna	7.2	4.1	4.9	22.5
Surti Paneer	3.4	2.0	2.5	40.0
Khoa	5.8	4.6	4.8	20.7
Rabri	5.7	3.3	3.6	25 to 30
Khurchan	8.5	5.0	5.8	15 to 20

100 kg. of milk with 4.0% fat yields approx. 13.0 kg. milk powder ;

100 kg of milk with 3.0% fat yields approx. 9.5 kg. ripened Cheddar type cheese ;

100 kg of milk with 3.0% fat yields approx. 33.5 kg. evaporated milk ;

100 kg. of skim milk approx. 9.5 kg. skim milk powder ;

100 kg. of skim milk approx. 7.5 kg. green casein ;

100 kg. of skim milk approx. 3.5 kg. dried casein ;

100 kg. of butter milk yields approx. 10.0 kg. butter milk powder ;

100 kg. of whey yields approx. 0.4 kg. whey butter ;

100 kg. of whey yields approx. 7.5 kg. whey cheese ;

100 kg. of whey yields approx. 3.5 kg. crude lactose.

1 litre of milk weighs approx 1032 gm

1 litre of skim milk weighs approx. 1035 gm

1 litre of cream with 25% fat weighs approx. 1008 gm

1 litre of buttermilk weighs approx. 1033 gm

12. Average Composition and Nutrients in Various Dairy Products (Per 100 gm.)

13. Approximate Water Consumption in Different Processes

Dairy Product	Fat	Protein	Carbohydrates	Ash	Total solids	Calcium	Phosphorus	Calories
Milk	%	%	%	%	%	mg	mg	
	3.0	3.2	4.7	0.70	11.6	115	86	59
	3.5	3.3	4.8	0.70	12.3	117	88	63
	4.0	3.4	4.8	0.70	12.9	118	90	69
	4.5	3.5	4.9	0.70	13.6	122	92	74
	5.0	3.6	4.9	0.70	14.2	124	93	79
	5.5	3.7	5.0	0.75	14.9	126	94	84
	6.0	3.8	5.1	0.75	15.6	128	96	90
	6.5	3.9	5.2	0.80	16.4	130	100	95
	7.0	4.0	5.2	0.80	17.0	132	102	100
Flavoured milk (with 65% sugar)	4.5	3.8	11.0	0.70	20.0	118	90	100
Skimmilk (Buffalo)	0.1	4.2	5.4	0.80	10.5	150	105	39
Skimmilk (Cow)	0.1	3.6	5.0	0.75	9.4	130	100	35
Cream	25.0	2.5	3.6	0.60	31.7	91	85	250
Butter (2% salt)	81.0	0.6	0.4	2.50	84.5	20	16	780
Buttermilk	0.5	3.7	4.8	0.70	9.7	118	90	39
Dahi	As per milk used with 5-7% concentration due to loss of moisture							
Ghee	99.5	0.1	0	0.10	99.7	0	0	896
Ice cream	10.0	5.0	17.6	0.80	23.4	150	120	180
Cheese-								
Cottage	4.0	15.4	2.5	1.30	23.3	98	165	108
Cheddar	32.2	25.0	2.1	3.70	63.0	725	495	398
Processed	29.9	23.2	2.0	4.90	60.0	675	487	370
Surti	20.5	9.3	2.3	1.90	34.0	250	200	231
Whey (dried)	0.5	13.0	74.5	8.50	96.5	572	542	355
Evaporated milk	8.0	7.0	10.9	1.50	26.4	250	200	144
Condensed milk	9.4	8.4	54.8	1.70	74.3	273	228	337
Milk powder	27.0	26.5	38.4	6.10	98.0	960	720	503
Skim milk powder	1.1	36.4	51.8	7.70	97.0	1294	960	363
Malted milk	5.8	8.4	82.0	0.80	97.0	200	620	414
Khoa-								
5% fat milk	25.5	18.2	22.6	3.54	69.8			406
7% fat milk	31.8	19.1	23.2	3.65	77.8			470
8% fat milk	36.1	20.1	22.8	3.83	82.9			513

*Lit. water / bottle; T.C.: Thermo-compressor

<i>Process</i>	<i>Lit. Water / Lit Milk</i>	<i>Lit. Water / kg Water Evap.</i>
Reception section	1.8	
Washing equipments	0.3	
Pasteurization	1.5	
Butter making	8.5	
Cheese making	2.0	
Sterilization		
Hydrostatic	1.0	
UHT direct	4.0	
UHT indirect	2.0	
Bottle washing	0.74*	
Evaporation		
1 Effect		17.0
1 Effect + T.C.	6.5	9.0
2 Effects	7.2	10.0
2 Effects + T.C.	5.0	7.0
3 Effects + T.C. + Preheaters	3.5	5.0
4 Effects + T.C. + Preheaters		4.0
5 Effects + T.C. + Preheaters		3.5

Source : Dairy India Year book, 2007 Edition six page 393

Annexures

ANNEXURE I.

Country wise Production and Consumption of Cheese

Country	Production/annum 000 MT	Consumption in kg, per person per annum
Top 10 Countries		
USA	4275 (2006)	14.8
Germany	1927 (2008)	22.6
France	1884 (2008)	26.1
Italy	1149 (2008)	20.9
Nether Lands	732 (2008)	21.0
Poland	594 (2008)	10.8
Brazil	495 (2006)	-
Egypt	462 (2006)	-
Argentina	425 (2006)	11.3
Australia	395 (2006)	12.0

ANNEXURE - II.

Important Breeds of Cattle and Buffaloes

(A) Indian Cow Breeds

Breed	Origin	Average Lactation Yield kg
Kankrej	North Gujarat	1300
Malvi	Madhya Pradesh	1100
Kenkantha	Bundelkhand, MP	Poor
Kherigaoh	Kheri in UP	Poor
Tharparkar	Sindh, Kutch	1660
Bachur	Bihar	Poor
Gaulao	Wardha Maharashtra, Madhya Pr	1000
Harvana	Rohtak, Delhi	1700
Nagori	Jodhpur, Rajasthan	800
Ongole	Guntur Andhra Pradesh	1400
Krishnakathi	Krishna Dt, Andhra Pradesh	1000
Mewati	Mathura, UP	800
Rathi	Alwar Rajasthan	1200
Gir	Kathiawar, Gujarat	2100
Deoni	Western Andhra Pradesh	1100
Dangi	Dang Dt. Gujarat	Poor
Nemari	Narmada Basin	400
Sahiwal	Punjab, Pakistan	2300
Red Sindhi	Karachi, Pakistan	2600
Amritmahal	Karnataka	1000
Hallikar	Tumkur Karnataka	Poor
Khillar	Solapur and Ahmednagar, Maharashtra	250
Kangayam	Coimbatore, T.N.	900
Lohani	Baluchistan Pakistan	900
Ponwar	Pilibhit, U.P.	Poor
Siri	Darjeeling, Sikkim	1800
Dhanni	Attuck Rawalpindi, Pakistan	1150
(B) Exotic Cow Breeds		
Holstein	Netherlands	7000
Friesian	Holland	
Jersey	Eurone	4000
Gurnsey	Gurnsey	5000
Brown Swiss	Switzerland	5000
Red Danish	Denmark	4500
Ayresshire	Scotland	5000
and (C) Buffalo Breeds		
Murrah	Rohtak, Hissar and Karnal, Harvana	1800
Nili-Ravi	Pakistan, Ferozpur, Punjab	1600
Surti	Kheda and Vadodara Gujarat	1600
Mehsana	Mehsana, Banaskantha, Gujarat	1900
Jafrabadi	Kathiawad, Gujarat	1800
Bhadavari	Agra, U.P	1250
Tarai	Tarai U.P	450
Nagpuri	Nagpur and Amravati in Maharashtra	900
Panrdharpuri	Solapur and Kolhapur in Maharashtra	900

ANNEXURE - III.**Top 12 States in Milk Production, 2007-08**

States/UTs	Milk Production ('000 tonnes)	Percentage to Total Milk Production (%)
Uttar Pradesh	18,861	17.99
Rajasthan	9,536	9.10
Punjab	9,282	8.85
Andhra Pradesh	8,925	8.51
Gujarat	7,911	7.55
Maharashtra	7,210	6.88
Madhya Pradesh	6,572	6.27
Bihar	5,783	5.52
Tamil Nadu	5,586	5.33
Haryana	5,442	5.19
Karnataka	4,244	4.05
West Bengal	4,087	3.90
Total (Top 12 States)	93,439	89.13
ALL INDIA	104,840	100.00

ANNEXURE - IV.**Statutory Permissions Required for the Project**

S.No	APPROVAL/LICENCE/NOC	AUTHORITY
1	Licence for MMPO	Dairy Department State Government .
2	EOU Registration	SIA (Delhi)
3	RBI Code	RBI
4	Import-Export Licence	JT. Director General of Foreigntrade
5	Industrial Entrepreneur MEMO	SIA (Delhi)
6	APEDA	Directorate of APEDA
7	63/1 Permission	Dist Collector
8	Land Conveyance	Dist Collector
9	N.A. Order	Dist Collector
10	Building Plans	Town Planning
11	Environmental NOC	Pollution Control Board
12	Power Sanction	Electricity Board
13	D.G.NOC	Electricity Board
14	D.G.Installation	ELEC. Inspector
15	Electrical Installation	ELEC. Inspector

S.No	APPROVAL/LICENCE/NOC	AUTHORITY
16	Power Release	Electricity Board
17	Factory Licence	Directorate of Industries
18	Boiler Installation	Industrial Boiler Rules
19	Scales & Balances	Weight & Measures
20	Building Completion	Town Planning
21	FDA Licence	Food & Drug Administrator
22	Sales Tax Registration	Sales Tax Department
23	Excise Licence	Excise Department
24	Building & Machinery Insurance	Insurance Company
25	Income Tax Registration	Income Tax Office
26	Providend Fund	P.F. Commissioner
27	ESIS/Insurance	ESI/Insurance Department
28	Contractor's Registration	Labour Commissioner
29	Package Incentive Scheme	Food Processing Industries
30	Telephones	P & T
31	Export Inspection Council Certificate	Export Inspection Agency

ANNEXURE - V.

List of Laboratory Equipment

Sr. No	Item Description	Specification	Qty.
1	Electronic Milk fat tester	120 to 150 test / hr	2
2	Gerber Centrifuge	1200 RMP	2
3	Butyrometer ISI marked	0-10% (milk)	100
4	Butyrometer for cream	Standard	10
5	Lock stoppers for milk butyrometer		50
6	Lock stopper key		10
7	Milk pipettes	10.75 ml.	20
8	Tilt Measure plastic	10/1 ml	20
9	Butyrometer shaking stand, plastic		5
10	Milk pipette stand for 12, plastic		5
11	Brushes for butyrometer or pipette		25
12	Mercury thermometer	110°C / 220°F	20
13	Pipette. Borosil glass	1.1 ml or 2.2 ml	20
14	Pipette Borosil glass	10 ml graduate	10
15	Burette corning glass	50 ml.	5
16	Funnel corning glass	3" dia	5
17	Volumetric flask corning glass	500 ml	5
18	Measuring cylinder graduated pour out corning glass	500 / 1000 ml	10

19	Glass beads		1 kg
20	Plastic sample bottles	100 ml	100
21	Reagent bottles	250 / 500 ml	10
22	Silica crucible	3" dia	5
23	Glass Funnel	3" diameter	5
24	Dark colored bottles	500 ml	5
25	Petri dishes	80 x 17	10
26	Incubator bacteriological	10" x 10" x 10"	1
27	Hot air oven	10" x 10" x 10"	1
28	Serological water bath for MBR test	2 stands complete	1
29	Water still (Automatic)	4 lit/hr	1
30	Digital pH meter	Standard	1
31	Lab. Hotplate circular, thermostate	8" dia	1
32	Dessiccator cabinet	2" x 20" x 14"	1
33	Colony counter	Digital display	1
34	Single pan balance	Standard	1
35	Top pan balance, capacity	2000 gms	1
36	Autoclave, rating – 6.0 KW	55"x76"	1
37	Microscope Binocular	100 x	1
38	Circular water bath to provide water at 40°C continuously	12"x10"x8"	1
39	Laminar flow inoculation chamber	4'x4'x4'	1
40	Digital Thermometer	-10 to 120°C	2
41	Solubility Index Mixer		1
42	Colorimeter		1
43	Brookfield Viscometer		1
44	Sediment Test		1
45	Soxhlet Extraction Heater		1
46	Micro Kjeldahl digestion & Distillation Unit		1
47	Bulk Density Apparatus		1
48	Autoclave (Horizontal)		1
49	Vacuum Oven		1
50	Incubator Shaker		1
51	Electronic Moisture Balance		1
52	On Line Water Analyser		1
53	Membrane Filter		1
54	BOD Measurement System		1
55	Turbidity Meter		1
56	Test Sieves		1
57	Lovibond Colour Instrument		1

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TECHNOLOGY OF DAIRY PRODUCTS

The present scenario of dairying in India is promising in many ways. The milk production per annum continues to place us on number one position in the world. This has opened up many opportunities for the Entrepreneurs to setup new ventures in the field of Dairy. This would require proper guidance on different aspects of dairying.

This book seeks to offer complete knowledge on various spheres of Dairy and Dairy Products. It will serve as a valuable resource for Entrepreneurs, Students, Researchers and Scholars. The book covers pre establishment as well post establishment processes and technicalities of Dairying.

CONTENTS AT A GLANCE

- Introduction
- General Description of Milk and Definitions of Milk and Milk Products
- Establishing A Dairy Plant
- Important Processes Used in a Dairy Plant
- Equipment Required in a Market Milk and Dairy Product Plants
- Market Milk and Other Milks
- Cream, Butter and Ghee
- Fermented Milk Products
- Coagulated Milk Products
- Desiccated Milk Products
- Mechanization of Manufacture of Traditional Dairy Products
- Cheese, Casein and Whey
- Evaporated and Sweetened
- Condensed Milk
- Manufacture of Nonfat Dry Milk and Dry Whole Milk by Spray Process
- Manufacturing of Ice Cream
- Recombined Dairy Products
- UHT Processing and Aseptic Packaging of Milk in Pouches
- Emerging New Technologies in the Dairy Industry
- Packaging of Milk and Dairy Products
- Use of Membrane Filtration in the Dairy Industry
- Cleaning in Place (CIP) System
- Energy Conservation through Technology Upgradation
- General Hygiene in a Dairy Plant
- Effluent Treatment in a Dairy Plant
- Dairy Professional's Ready Reckoners
- Dairy Calculations and Formulations

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