Online Training For Master Trainers On Dairy Processing

आत्मनिर्भर भारत

28th Dec 2020 - 1st Jan 2021

Organized by

Dairy Technology Division
ICAR-National Dairy Research Institute
Karnal, Haryana

Sponsored by IIFPT, Thanjavur under the aegis of MOFPI's PM-FME Scheme

ndri

IIFPT

Online Training for
Master Trainers on Dairy Processing

28th December 2020 – 1st January 2021

आत्मनिर्भर भारत

Coordinators

Dr. Ashish Kumar Singh
Principal Scientist

Dr. Narender Raju Panjagari
Scientist (Sr. Scale)

Sponsored by

IIFPT

Indian Institute of Food Processing Technology, Thanjavur, Tamil Nadu
under the aegis of Prime Minister's – Formalization of Medium and Small Enterprises (PM-FME) Scheme of Ministry of Food Processing Industries, Govt. of India

Organized by

Dairy Technology Division
ICAR-National Dairy Research Institute
Karnal, Haryana

www.ndri.res.in

Published by:

Dr. M.S. Chauhan
Director
ICAR-National Dairy Research Institute
Karnal, Haryana (India)
Email: director.ndri@icar.gov.in

Cover Page Design:

Dr. Narender Raju Panjagari
Scientist (Sr. Scale)
Dairy Technology Division
ICAR-NDRI, Karnal

Compilation and Editing:

Dr. Narender Raju Panjagari
Scientist (Sr. Scale)
Dairy Technology Division
ICAR-NDRI, Karnal

Dr. Ashish Kumar Singh
Principal Scientist
Dairy Technology Division
ICAR-NDRI, Karnal

Online (Zoom) Support:

Mr. Rakesh Kumar Raman
Technical Officer
Dairy Technology Division
ICAR-NDRI, Karnal

Table of Contents

Online Training for Master Trainers on Dairy Processing

(Sponsored by IIFPT, Thanjavur under the aegis of MOFPI's PM-FME Scheme)

Lecture / Demo Schedule

Sr. No.		Date	Time	Topic	Faculty / Resource Persons	Lecture Mode: Theory / Demo
DAY-1		28-01-2020	09.30 AM-09.35 AM	Virtual Assembly / Joining of Participants		
		28-01-2020	09.35 AM-09-45 AM	Welcome Address	**Dr. Ashish Kumar Singh** Principal Scientist, Dairy Technology Division & In-Charge, Business Planning & Development Unit, ICAR-NDRI, Karnal	
		28-01-2020	09.45 AM-10.00 AM	Inaugural Address	**Dr. Manmohan Singh Chauhan** Director, ICAR-National Dairy Research Institute, Karnal	
	1	28-12-2020	10.00 AM-10.30 AM	Overview of PMFME scheme, guidelines, objectives, capacity building framework and its implementation.	**Dr. C. Anandharamakrishnan** Director, Indian Institute of Food Processing Technology (IFPT) Thanjavur	Theory
	2	28-12-2020	10.30 AM-11.30 PM	Status, Market Size and Scope of Dairy Processing Industry in India	**Dr. Latha Sabikhi** Principal Scientist & Head Dairy Technology Division, ICAR-NDRI, Karnal	Theory
	3	28-12-2020	11.30 AM-1.00 PM	Dairy Processing Equipment: Selection, Specifications and Installation	**Prof. S. Ravi Kumar** Former Associate Dean College of Dairy Technology SVVU, Tirupathi	Theory
		28-12-2020	1.00 PM – 2.00 PM	Lunch Break		

	4	28-12-2020	2.00 PM-3.30 PM	Maintenance of Dairy Processing Equipment	**Er. Ankit Deep** Scientist Dairy Engineering Division ICAR-NDRI, Karnal	Theory
	5	28-12-2020	3.30 PM-5.00 PM	Practical Aspects of Maintenance of Dairy Equipment	**Er. Ankit Deep** Scientist Dairy Engineering Division ICAR-NDRI, Karnal	**Demo**
DAY-2	**6**	29-12-2020	9.30 AM-11.30 AM	Dairy Processing Utility Equipment: Selection, Specifications and Installation	**Dr. J.K. Dabas** Chief Technical Officer & In-Charge, Maintenance Engg. Section ICAR-NDRI, Karnal	Theory
	7	29-12-2020	11.30 AM-1.00 PM	Dairy Plant Layout	**Er. Ankit Deep** Scientist Dairy Engineering Division ICAR-NDRI, Karnal	Theory
		29-12-2020	1.00 PM – 2.00 PM	Lunch Break		
	8	29-12-2020	2.00 PM-4.00 PM	Processing of Milk and Value-Added Dairy Products	**Mr. Gaurav Kr. Deshwal** Scientist Dairy Technology Division ICAR-NDRI, Karnal	Theory
	9	29-12-2020	4.00 PM – 5.00 PM	Cleaning and Sanitization of Dairy Processing Equipment	**Dr. Ganga Sahay Meena** Scientist (Sr. Scale) Dairy Technology Division ICAR-NDRI, Karnal	Theory
DAY-3	**10**	30-12-2020	09.30 AM-11.00 AM	Manufacture of Traditional Indian Dairy Products: An Overview	**Dr. Kaushik Khamrui** Principal Scientist, Dairy Technology Division ICAR-NDRI, Karnal	Theory
	11	30-12-2020	11.00 AM – 1.00 PM	Packaging of Dairy Products	**Dr. P. Narender Raju** Scientist (Sr. Scale) Dairy Technology Division ICAR-NDRI, Karnal	Theory

		30-12-2020	1.00 PM – 2.00 PM	Lunch Break		
	12	30-12-2020	2.00 PM – 3.15 PM	Processing of Milk and Value-Added Dairy Products (Practical)	**Mr. Gaurav Kr Deshwal** Scientist Dairy Technology Division ICAR-NDRI, Karnal	**Demo**
	13	30-12-2020	3.15 PM – 4.30 PM	Ice Cream and Frozen Desserts (Practical)	**Dr. Shaik Abdul Hussain** Scientist Dairy Technology Division ICAR-NDRI, Karnal	**Demo**
	14	30-12-2020	4.30 PM-5.30 PM	Testing of Packaging Materials and Demonstration of Packaging Techniques	**Dr. P. Narender Raju** Scientist (Sr. Scale) Dairy Technology Division ICAR-NDRI, Karnal	**Demo**
DAY-4	**15**	31-12-2020	9.30 AM-10.30 AM	Need for Testing of Food and Notified NABL and Reference Labs in India	**Dr. Rajan Sharma** Principal Scientist & In-Charge, National Reference Centre for Milk Quality and Safety, ICAR-NDRI, Karnal	Theory
	16	31-12-2020	10.30 AM-12.00 PM	Food Quality and Safety Management Practices Relevant to Dairy Industry	**Dr. Raghu H.V.** Scientist (Sr. Scale) Dairy Microbiology Division ICAR-NDRI, Karnal	Theory
	17	31-12-2020	12.00 PM-1.00 PM	FSSAI Food Packaging and Labelling Requirements	**Dr. P. Narender Raju** Scientist (Sr. Scale) Dairy Technology Division ICAR-NDRI, Karnal	Theory
		31-12-2020	1.00 PM-2.00 PM	Lunch Break		
	18	31-12-2020	2.00 PM-3.00 PM	FSSAI and FBOs Registration and Licensing Procedure	**Dr. Richa Singh** Scientist Dairy Chemistry Division ICAR-NDRI, Karnal	Theory
	19	31-12-2020	3.00 PM-4.00 PM	Requirements for Establishment of a Chemical Quality Assurance Laboratory	**Dr. Rajan Sharma** Principal Scientist & In-Charge, National Reference Centre for Milk Quality and Safety, ICAR-NDRI, Karnal	**Demo**

	20	31-12-2020	4.00 PM-5.00 PM	Requirements for Establishment of a Microbial Quality Assurance Laboratory	**Dr. Raghu H.V.** Scientist (Sr. Scale) Dairy Microbiology Division ICAR-NDRI, Karnal	**Demo**
DAY-5	**21**	01-01-2021	9.30 AM-10.30 AM	Importance of Soft Skills and Communication for Dairy Entrepreneurs	**Dr Pratima Khandelwal** Lead Facilitator- Life Skills and Faculty Mentor Founder- FlyHigh (MSME Unit), Bengaluru	Theory
	21	01-01-2021	10.30 AM-11.30 PM	Networking Skills, Creative and Innovative Thinking and Problem Management		Theory
	22	01-01-2021	11.45 PM-1.00 PM	Leadership and Team Building		Theory
		01-01-2021	1.00 PM – 2.00 PM	Lunch Break		
	23	01-01-2021	2.00 PM-3.00 PM	Dairy Entrepreneur Competencies: Risk taking and Goal Settings	**Dr. Pratima Khandelwal** Lead Facilitator- Life Skills and Faculty Mentor Founder- FlyHigh (MSME Unit), Bengaluru	Theory
	24	01-01-2021	3.00 PM-4.30 PM	Team Building and Effective Communication Skills		**Demo / Self-Learning**
	25	01-01-2021	4.30 PM-5.30 PM	Assessment by FICSI		

Online Training of Master Trainers - Milk and Milk Products Processing

List of Nominated Participants

S. No	Name & Designation	Nominated by which State Nodal Agency	Organization	Mobile No :	Email Address :
1	**Dr. Vijay B. Parmar** Veterinary Officer	Dadra and Nagar Haveli and Daman and Diu	Department of Animal Husbandry and Veterinary Services, DNH&DD PIN Code: 396220	9998963573	drvijaydpdnh@gmail.com
2	**Nitin Kumar** Assistant Professor	Haryana	NIFTEM Kundli - 131028	8199902055	nitinkumar.iit@gmail.com
3	**Dr. Arup Das** Senior Technical Assistant	Meghalaya	Department of Food Engineering & Technology, Tezpur University PIN Code: 784028	8822279573	arupdas@tezu.ernet.in
4	**Ashish Balkrishna Raskar** Training Coordinator	Maharashtra	ADT, KVK, Baramati PIN Code: 413115	9921587143	raskarab04136@gmail.com
5	**Dr. Sanjivani Prakash Waghmare** Assistant Professor cum Training Manager	Maharashtra	ADT, KVK, Baramati PIN Code: 413115		sanjivaniwaghmare13@gmail.com
6	**Dr Prabhat Kumar Mandal** Professor	Puducherry	Rajiv Gandhi Institute of Veterinary Education and Research (RIVER), Kurumbapet, Puducherry -605 009	9489585699	mandalpkm@gmail.com
7	**Dr.S.Kasthuri** Assistant Professor (On Contract)	Puducherry	Rajiv Gandhi Institute of Veterinary Education and Research (RIVER), Kurumbapet, Puducherry -605 009		drkasthurilpt@gmail.com

8	**Dr. Safia N E** Assistant Professor	Kerala	Kerala Agricultural University, Thrissur PIN Code: 673593	7561806901	safiya.ne@kau.in
9	**Archana Chandran** Assistant Professor	Kerala	Kerala Veterinary and Animal Sciences University, Wayanad PIN Code: 673576	9744975460	archanac@kvasu.ac.in
10	**Dr. Ruma Devi** Assistant Professor	Uttar Pradesh	Acharya Narendra Deva University of Agriculture and Technology, Kumargan, Ayodhya PIN Code: 224229	9415790120	rumadevi.2@gmail.com
11	**Dr. (Miss) Jessy Bag** Assistant Professor	Odisha	College of Vety. Sc & AH, OUAT, Bhubaneswar PIN Code: 751003	7377731290	jessybagh123@gmail.com
12	**Dr. Rajni Modgil** Professor	Himachal Pradesh	CSKHPKV Palampur PIN Code: 176062	9816123291	rajni_modgil1@yahoo.com
13	**Priyanka Bhattacharjee** Microbiologist	Tripura	Medicaids Package Drinking Water plant PIN Code: 799001	7005192008	pri.bhattacharjee2@gmail.com
14	**Dr. Chiragkumar Balvantbhai Rathod** Head Skill Development	Gujarat	The Centre for Entrepreneurship Development PIN Code: 382017	9909949523	cplt-ced@gujarat.gov.in
15	**Dr. Suiding** VAS	Nagaland	Directorate of Animal Husbandry & Veterinary Services, Government of Nagaland PIN Code: 797001	8794913220	dr.suiding@gmail.com
16	**Dr. Neeraj Mishra** Scientist	Chattisgarh	FAE, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) PIN Code: 492001	9575256562	nkm111@rediffmail.com

17	**Dr. Ranjeet Rajput** Sr. Scientist & Head	Chattisgarh	KVK Koriya (C.G.) PIN Code: 497559	9479025559	maneetraj@yahoo.co.in
18	**Er. Gitesh Sinha** Subject Matter Specialist	Chattisgarh	KVK Balod (C.G.) PIN Code: 491226	8878165265	geeteshsinha20@gmail.com
19	**Susanta Kar Choudhuri** General Manager I/C	Tripura	Dharmanagar Dairy PIN Code: 799250	9862779752	susantakc1986@gmail.com
20	**Dr. Mahendra Kumar Srivastava** Retired Senior Chemist	Uttar Pradesh	Retired from Pradeshik Cooperative Dairy Federation Limited, Lucknow (Parag) Working as consultant in DUSS Lucknow PIN Code: 226016	7905496115	mahendra_sri19@rediffmail.com
21	**Dr. P. K. Pat** Professor and Head	Odisha	College of Vety. Sc & A.H., OUAT, Bhubaneswar PIN Code: 751008	9861137609	drpkpatiovc@gmail.com
22	**Dr. H. Arunkumar** Professor	Karnataka	Dairy Science College, KVAFSU, Hebbal, Bangalore-24 PIN Code: 560094	9449179928	arunhruday@rediffmail.com
23	**Dr. M.Venkatesh** Professor	Karnataka	Dairy Science College, KVAFSU, Hebbal, Bangalore-24 PIN Code: 560097	9449356263	venkatm1965@rediffmail.com
24	**Dr Karun Chandalia** Managing Director	Rajasthan	RCDF – Saras PIN Code: 306401	9928016309	karun5128@gmail.com
25	**Shri Kamlesh Meena** Assistant Professor, CDFT	Rajasthan	MPUAT, Udaipur PIN Code: 313001	9680184316	kamleshrj@gmail.com
26	**Dr Arun Goel** Assistant Professor, CDFT	Rajasthan	MPUAT, Udaipur PIN Code: 313001	9887182750	arungoel09@gmail.com
27	**Dr. Gopika Arora** Assistant Professor	Punjab	GADVASU Ludhiana-141004	9876578765	talwargopika@gmail.com

28	**Dr. Amandeep Sharma** Assistant Professor & Head	Punjab	GADVASU Ludhiana-141004	9888881993	drsharma.aman@gmail.com
30	**L. Sada Siva Rao** Manager	Andhra Pradesh	Dodla Dairy PIN Code: 533003	9000005564	sadasiva.lolugu1978@gmail.com
31	**Dr. Rakesh Kumar Raigar** Assistant Professor	Sikkim	College of Agricultural Engineering and Post Harvest Technology PIN Code: 737135	9474682664	rakeshiitkgp07@gmail.com
32	**Asif Ali Baig** Regional Quality Assurance Manager	Telangana	Arabian Food Supplies PIN Code: 500016	9959702779	asif.ab@outlook.com
33	**Sandeep** Regional Quality Assurance Manager	Telangana	Allama Sons India Limited PIN Code: 500010	9676126357	ksg.sandeepgoud@gmail.com
32	**Sunil C K** Assistant Professor	Tamil Nadu	IIFPT Thanjavur-613005	9750968423	sunil.ck@iifpt.edu.in
34	**Dr. Aparna Agarwal** Assistant Professor	Delhi	Lady Irwin College New Delhi-110070	9958211704	aparna.gupta@lic.du.ac.in
35	**S.G. Shree Hari Reddy** Manager	Tamil Nadu		9865265587	aavinvellore.dairy@gmail.com
36	**B. Balasankar** Deputy Manager	Tamil Nadu		9094754475	micro120986@gmail.com

Status, Market Size and Scope of Dairy Processing Industry in India

Latha Sabikhi

Principal Scientist & Head
Dairy Technology Division, ICAR-National Dairy Research Institute, Karnal

Introduction

When one talks of any business, what come to mind first, are the sustainability of the venture and the profit margin. In this context, dairying in India is more about livelihoods of millions of farmers rather than a business. Milk is India's single largest agricultural commodity terms of value, which is more than the combined value of paddy and wheat. This is despite the fact that almost three fourths of the milk produced in India comes from small, marginal and landless farmers whose resource availability and land holding are comparatively much lesser than the farmers growing other agricultural produce. The dairy industry is the largest contributor to the agricultural GDP. Milk is the primary source of liquidity and supplementary income for over 100 million farmers in India, most of who fall under the bracket of marginal and landless. In addition, milk is also the only source of a daily income to meet the daily household expenses. This alone is a pointer to learn from the processes and institutional mechanisms of Indian dairying.

Agricultural process in India - Dairying *vs.* conventional agriculture

The Indian farmers have to be involved in multiple agricultural activities to ensure steady income generation. Diversification of agricultural activities is imperative to their economic welfare. They can earn better remuneration for their produce through co-operative ventures. It is unfortunate that the Indian farmer does not get a remunerative price for his produce, despite it selling in urban markets for several folds more than what he gets. The benefits of price escalation are not transmitted proportionately to the producer of the commodity. For example, when an urban consumer pays Rs. 60 for a kilo of onions, the farmer who produces it in the rural fields receives one tenth of that price. This is despite the fact that in the pandemic era, when industrial production has fallen low, the employment as well as the output in the farming sector has seen a significant increase. The key challenge, therefore, in the agricultural sector is to transfer remunerative prices to the farmers for their produce. In contrast to their agricultural commodities, the dairy industry in India transfers up to 80% of the consumer price to dairy farmers. This is much more than the global practices, with Australia, New Zealand and the European countries paying respectively, 25%, 33%

and 30-40% to their producers. There is no Minimum Support Price (MSP) for milk, unlike for other major agricultural commodities. The co-operative structure has been adopted in some other sectors of agriculture, but these are perforated by middlemen across the supply chain and hence, have not achieved the efficiency and professionalism seen in the dairy co-operative sector.

Current market size of the Indian dairy industry

India's milk-producing journey has been momentous over the past seventy years, from 17 million tonnes in 1950 to 193 million tonnes in 2020. From being a net importer of dairy products only a few decades ago, India's milk production grew at a CAGR of 4.5% compared to 1.8% in the US and 1.3% in the EU and Australia. The dairy sector has become among the highest gross value sectors in agriculture, reaching a value of Rs. 10,540 billion in 2019 with higher prices and correspondingly higher value of milk production. The IMARC Group estimates that the **Indian dairy market** is estimated to reach a value of Rs. 21,971 Billion by 2024, exhibiting a CAGR of ~ 16% during the 2019-2024. This feat has been possible by the remarkable efforts of a large number of small milk producers spread across the rural areas of the country. This strategy of organising and institutionalising of milk production has become an eye-opener for the traditionally well-established dairy producing countries across the globe. There are about 100 million farmers in India who are dependent on dairy, compared to about 10,000 in New Zealand and 6,300 in Australia. The only difference is the size of the individual farms, with an Indian dairy farmer possessing 2-3 animals, whereas his Australasian counterparts have 2000 to 3000 heads of cattle. It is important to note that the socio-economic impact of the dairy sector as a means of livelihood to these millions of farmers is much more distinct in India compared to any other major milk producing and exporting countries.

India and the global dairy sector

India has, over the years, built a robust cooperative system involving small milk producers. This social system encompasses, besides the dairying, micro-banking, health initiatives, educational incentives and other socio-cultural benefits. The co-operatives are owned by these small producers, and not by large corporates and companies as in other dairying countries. Entering into free trade pacts with the major dairying countries will put India at a disadvantage. For example, if milk and milk products from dairying countries such as Australia and New Zealand enter the Indian market, it is possible that procurement of milk from farmers in India will decline. Manufacturers will

import from foreign companies if their prices are lower, thereby damaging local dairy farmers' livelihoods. India pulled out of the Regional Comprehensive Economic Partnership (RCEP) with partner countries in May this year, largely owing to protests from the dairy industry. India being the largest dairy producer in the world with a target of 330 Million MT by 2034, experts feel that that if other RCEP countries are permitted in the Indian market, the domestic production will collapse. New Zealand, an RCEP member, with 3.5 million tonnes of milk exports will reap the highest benefits of the partnership. In contrast, India's export share is pathetic, with a mere 172,000 tonnes, despite her huge volumes of milk production.

Dairy processing in India

The primary factor that encourages the market growth of dairy products is the rise in population as well as the increasing in purchasing power. Owing to more disposable income, more and more consumers spend more on milk and milk products. The changing demographics of the population, with ethnicity and health-consciousness going hand in hand, there is a visible shift towards organic dairy products. Owing to the rise in the working population, the time available to cook food is reducing and the demand for ready-to-eat products is soaring. In addition, there are several subsidies that the Government of India is providing to promote the processing of milk into products. While liquid milk dominates the dairy industry in India, there is also renewed focus on flavoured and frozen yogurt, cheese, UHT milk, flavoured milk, curd, *lassi*, buttermilk, probiotic dairy products, table butter, *ghee*, *paneer*, *khoa*, skimmed milk powder (SMP), dairy whiteners, ice cream, dairy sweets, cream, whey and sweetened condensed milk.

Uttar Pradesh leads the investments in establishing milk processing plants, followed by Rajasthan, Gujarat, Madhya Pradesh, Andhra Pradesh and Punjab. The market is extremely disjointed, with many small and large manufacturers competing in terms of prices and quality. Owing to this rigid competition, small players often find it tough to survive in the market. Some of the major private dairy firms are Hatsun Agro Product Ltd., Heritage Foods India Ltd., Milk Food Ltd., Mother Dairy Fruits & Vegetables Pvt. Ltd., Nestlé India Ltd., Tirumala Milk Products Pvt. Ltd., etc. The leading co-operatives are Gujarat Co-operative Milk Marketing Federation Ltd., Karnataka Co-operative Milk Producers Federation Ltd., Punjab Co-operative Milk Producers Federation Ltd., Rajasthan Cooperative Dairy Federation Ltd. and Tamilnadu Cooperative Milk Producers Federation Ltd.

The dairy co-operatives in India are structured in such a way that the farmers own the processing plants, which are manned by highly competent technical personnel. Many of these dairy processing plants are of massive capacities, surpassing those of the private and corporate dairy processing plants in the country as well as in other dairying countries. The major constraint that the dairy market is witnessing is the lack of adequate cold chain facilities. Dairy products being a perishable commodity with a low shelf-life require a continuous, reliable as well as economic cold chain infrastructure for storage and transportation.

Value addition for increasing farmers' income

The Indian dairy industry is slowly converting itself from a fluid milk industry to a value added dairy products market. The share of premium dairy products in the organised dairy industry is 8-10% and is expected to grow at a pace of 6-8% per year, achieving a market share of ~ 20% in 2021. The disposal of milk should be commensurate with income generation and then only will the farmers' income increase. Every dairy plant has a standard product basket, which may include liquid milk, products such as *dahi*, *lassi*, *paneer*, some sweets, butter, *ghee* and SMP. Converting milk into SMP is no more a profitable alternative. Returns always come from products that sell and that that the consumer buys. These may range from what the common man purchases to luxury items that sell at a premium price. They include dairy-based beverages, high fat, coagulated, fermented and dried products, ready-to-eat and ready-to-serve formulations, nutrient-fortified and formulations targeting health and well-being. As nearly 30% of the Indian population is vegetarian, milk and milk products constitute the only source of animal protein in the diet of such people. This gives the opportunity to present dairy products, particularly those with high or added protein contents as health foods. As milk lacks in fiber and iron, combining dairy with plant-based food ingredients such as cereals, fruits and vegetables enriches the final product with these nutrients. Composite dairy products, thereby, have earned a special place in the current dairy market. Pre- and probiotics are being positioned as functional dairy foods. Special varieties are being developed and patented, either as specific organisms or as part of a food formulation.

Profits come from value addition. The value realised from the sale of the products must find their way back to the producers. On the model of the large dairy co-operatives, small dairy farmers should be advised to converge into Self Help Groups and farmer producer companies that process the milk, even if at small scale. It is encouraging that several such groups have been formed and

are earning profits. The greatest advantage is that the middlemen who used to reap the benefits are totally done away with in this arrangement, as the procurement, production and marketing are all done by members of the groups.

Conclusion

Indian dairy industry has come a long way from collection and supply of fluid milk for direct consumption to exporting a few traditional products, particularly *paneer* and *channa* based sweets such as *rasogolla* and *sandesh*. However, India's role in global trade is miniscule. India has one of the lowest costs of production globally and is geographically close to milk-deficit markets such as South, South-east and West Asia. These two factors call for exploring the opportunities in capturing these markets with value added products. There is tremendous scope for widening the product range including traditional value added products to cater to the Indians living abroad. The success of a value-added dairy business will ultimately depend on the commitment, social and institutional support and sustainability.

Selected reads:

1. 2020https://dairynews7x7.com
2. http://www.businessworld.in/article/Milk-Production-Expected-to-Increase-This-Year/27-02-2020-185089/
3. https://www.dairyglobal.net/Market-trends
4. https://www.imarcgroup.com/dairy-industry-in-india
5. https://www.mitsui.com/mgssi/en/report/detail/__icsFiles/afieldfile/2017/12/22/170907x_nozaki_e.pdf
6. https://www.suruchiconsultants.com

*****

Dairy Processing Equipment Selection, Specifications and Installation

Prof. S. Ravi Kumar
Former Associate Dean, College of Dairy Technology
Sri Venkateshwara Veterinary University, Tirupati, A.P.

Introduction: Milk being the most perishable of the agricultural commodities, needs to be chilled and processed with least time delay. In fact, the poor-quality milk will yield only poor-quality milk products on processing. The equipment also needs to maintain high standards of hygiene. They also need to be cleanable with suitable acid and alkali, immediately after use.

General aspects of equipment selection: The following are aspects common to be taken care of during purchase of equipment.

1. The equipment must meet the maximum handling of milk and milk products, as the milk production peak is seasonal.
2. Equipment must be compatible to the other related equipment, upstream or downstream of the processing sequence. It may be in terms of capacity, size, fittings, threaded joints etc.
3. Must meet all the hygiene requirements, and should be self- draining, without leaving any remnants of milk, water or cleaning solutions. **(Fig. 1)**.

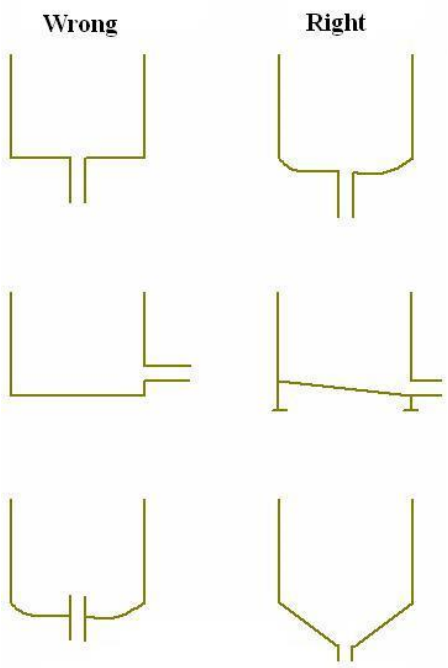


Fig. 1. Aspects of Sanitary design of equipment

4. All product contact surfaces must be of stainless steel of grade SS 304 or SS 316, of smooth surface finish of at least 150 grit (0.4 Ra), and pacified by suitable chemical treatment.
5. Strictly follow the manufacturer's instructions of installation, operation and maintenance, as they understand the equipment the best.

Fig. 2. Parts of Plate Heat Exchanger

Chilling equipment: After receiving the milk, and testing for acceptance and quality, the first and foremost of the dairy plant operations is chilling of milk below to 4^{o}C. It is done mostly by Plate chiller **(Fig. 2)**, in which the stainless-steel corrugated plates are arranged to hang to a frame, with gaskets in between, to maintain a narrow gap. The milk flows in alternate gaps, and the chilled water, which is normally twice the flow rate of milk, flows in the adjacent gaps. Because of the narrow passage, the milk gets cooled within seconds, unlike farm Bulk Milk Cooler, which take around 3 hours. But you need chilled water available at 1 to 1.5^{o}C, with facility to recirculate at required flow rate and bring the temperature back to the required temperature. This is usually done by Ice Bank Tank and a refrigeration system of suitable capacity. The size of the plates and corrugations depend on the product to be processed, whether heating, cooling, evaporation or condensing, and find use across the food and dairy industry, for wide areas of applications (Fig. 2).

Nowadays, the entire system is available on skid mounted supports and easy to install and shift, instead of large tanks and equipment.
Specifications are: 1) Flow rate / h of process and service fluids 2) Type of process fluid 3) The cooling duty
Finally, after chilling, the milk has to be stored in an insulated tank of suitable capacity.

Milk Storage Tanks: The chilled milk has to be stored in an insulated tank (**Fig. 3**), that is insulated (usually by expanded polystyrene, or thermocole) to maintain the milk in chilled condition for sufficiently longer time till it is further processed. The tank has features like, agitator, sight glass, light glass, adjustable legs, temperature indicator, sampling cock, manhole door, air outlet, milk inlet of non foaming type, milk outlet of suitable size and valve. Inside the tank, there are gradations (made by food grade paint or with buffing) to indicate the quantity of milk. The inner edges should be curved so that cleaning operations is effective, and the sloping is towards outlet, so that complete draining of milk or cleaning solutions is achieved. The tank must have lifting eye fitted on top to unload or load the tank from transport vehicle, without damage to the tank.

It has to be installed simultaneously, while the civil works of the dairy plant is taking place, as once the works are finished, the installation of tank is not possible without breaking the wall. Or

else, the processing hall must have large sized opening with shutter. The sloping of the tank should be adjusted to the direction of milk outlet, irrespective of the sloping of floor, which is usually towards the drainage.

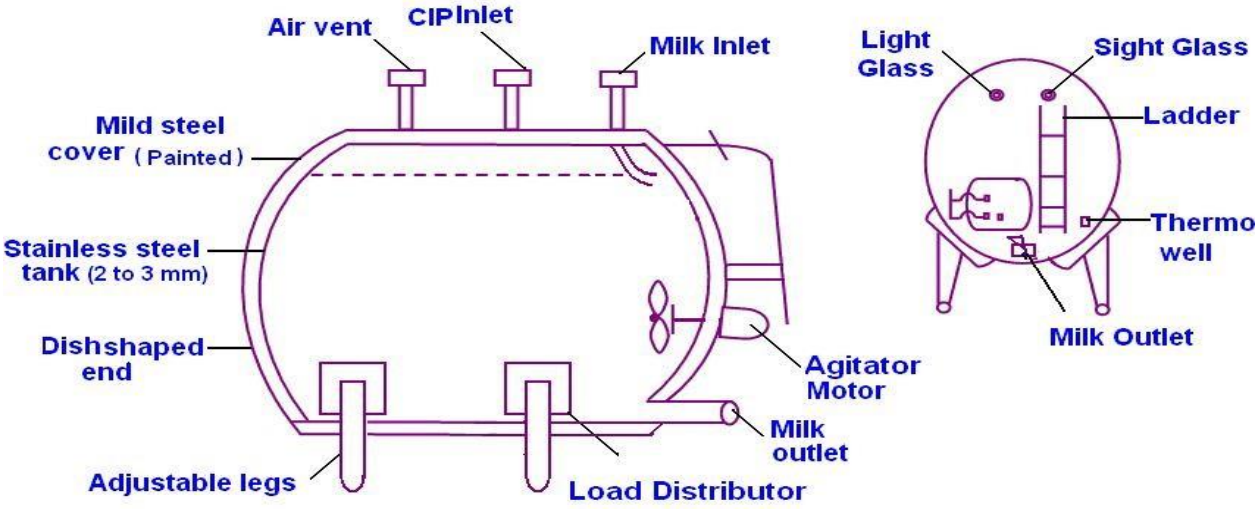


Fig. 3. Parts of Horizontal milk storage tank

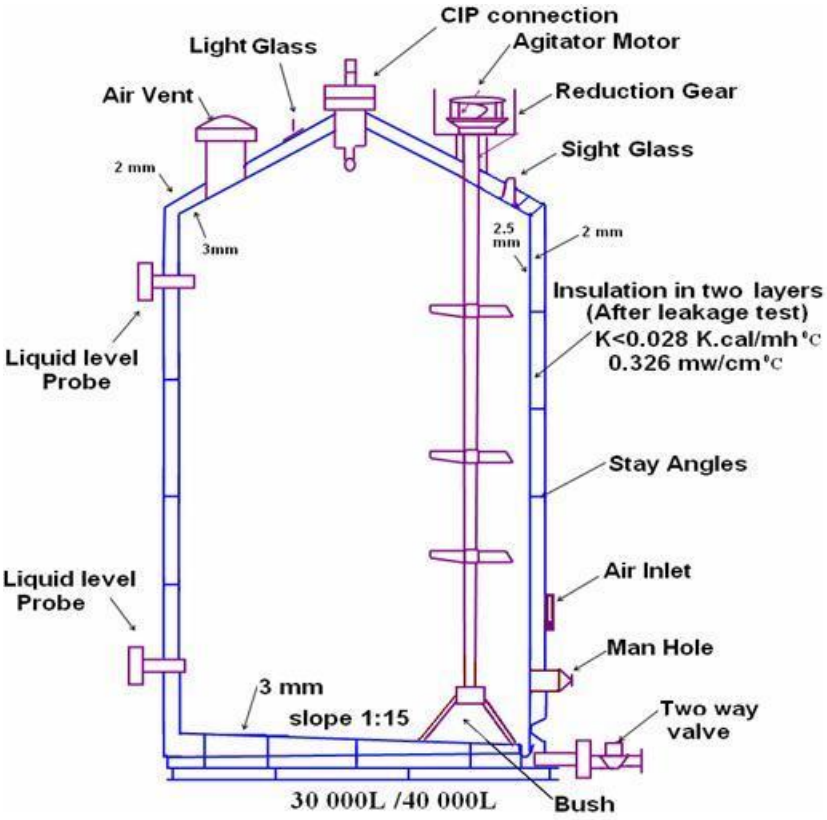


Fig. 4. Parts of Vertical Storage Tank

Milk storage tanks of large capacity, usually more than 30.000 to 1,00,000 are in the form of silos (**Fig.4**), and are located outside the processing hall, with an opening through alcove, to load or unload milk through pipe lines, controlled by pneumatically operated valves (especially for large tanks).

Milk is also transported in storage tanks, like mini trucks (for below 5,000 lts), road tankers (up to 20,000 lts) or rail tankers (upto 40,000 lts), and have suitable support systems to suit to the chassis of the transport vehicle. The tanks usually have compartments to prevent rolling over of large quantity of liquid, and cause difficulties in driving the vehicle.

Specifications are : 1) Nominal capacity of storage 2) Stationary or mobile 3) Horizontal or Vertical 4) Accessories like temperature measuring, level measuring either at the tank or remote sensing

Pasteurizers: The objective of Pasteurization is to kill all pathogenic organisms and most of the non-pathogenic organisms. The milk from storage tank is fed to the Pasteurizers. It has to be heat treated to temperatures of at least 72^{o}C for 16 seconds (High Temperature Short Time) or at 63^{o}C for 30 minutes (Low Temperature Longer Time). Usually, LTLT process is used for batch process, for smaller quantities, done in a tank with provision of heating and cooling, in the surrounding jacket, and an agitator inside for maintaining uniform temperature throughout the vessel. In both the processes, cooling immediately below 4 ^{o}C is essential, so as to give thermal shock to the bacteria and effective killing of the same. Under Indian conditions of poor initial quality of milk, however, the heating up to 78 ^{o}C, is now common, which can only be brought down, if the quality of raw milk is improved considerably.

The equipment for HTST pasteurizer (**Fig. 5**), is a combination of sections of Plate Heat Exchangers, as in Chillers, but here, they are arranged in a sequence, to bring the milk from storage tanks (stored at below 4^{o}C) rapidly to the pasteurization temperature of above 72 ^{o}C, and immediately brought to cooler temperature of 4 ^{o}C. The incoming raw milk is heated to some higher temperature by the returning hot milk, so that the hot milk is also simultaneously cooled to certain lower temperature (in section called Regeneration section), before it is ultimately cooled to below 4^{o}C. Thus a saving of 85 to 90 % of heating or cooling range of milk is achieved without

the necessity of hot water or chilled water. The milk, after Regeneration, will be about 60°C and is further heated to pasteurization temperature by hot water (in heating section), and then passed through Holding section for 16 seconds. At the end of Holding section, a temperature sensor detects the temperature of milk and compares the same with the desired, pre-set temperature. If the condition is satisfied, then with a pneumatically operated valve, called Flow-Diversion Valve(FDV), the milk will be passed again to Regeneration section to heat the incoming raw milk. If the temperature is below the set-point, then, the milk is diverted by the FDV, back to the starting point, that is the balance tank, to go through the same process of heating and cooling.

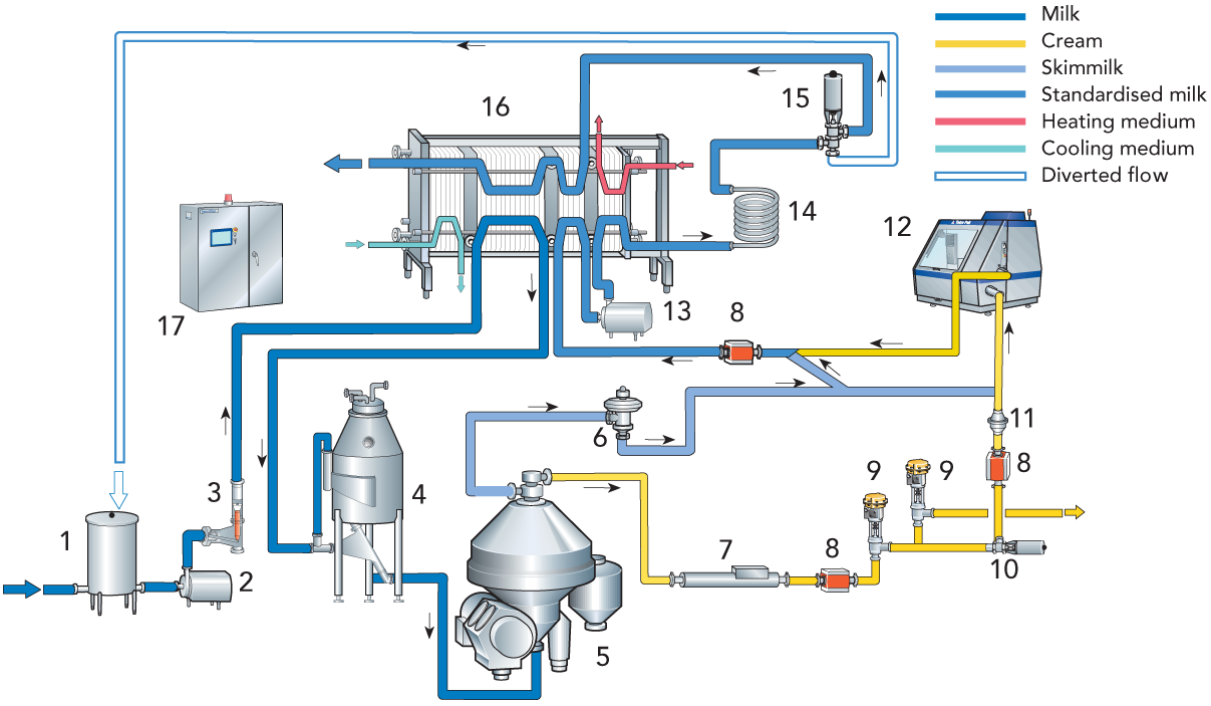


Fig. 5. Flow diagram of HTST pasteurizer along with Cream Separator and Homogenizer

1. Balance Tank 2. Milk feed pump 3. Flow Controller 4. Deaerator 5. Separator
6. Constant Pressure Valve 7. Density Transmitter 8. Flow Transmitter; 9. Regulatory valve 10. Shut off valve 11. Check valve 12. Homogenizer; 13. Booster pump 14. Holding Tube 15. Flow Diversion Valve 16. Plate Heat Exchanger 17. Process Control

(Source: Tetra Pak Handbook)

In the practical arrangement in processing of milk in HTST pasteurizer, the milk passes through Regeneration section I and after reaching about 40°C is passed to Cream Separator, and then on return, is fed to Regeneration section II, for further heating to about 60°C. The outlet and inlet of milk at Regeneration section is done through connecting plates, which hold the pipeline connections. After Regeneration section II, the milk may pass to Homogenizer, and on return, is

passed to Heating section, and then to Holding section. After FDV, the properly pasteurized milk passes through Regeneration section again, and then to Cooling section, where the milk is cooled by Chilled water, similar to Plate Chiller, discussed earlier.

The Controls of HTST pasteurizer are important, and may also include a temperature recording system so that the time-temperature combination is known, throughout the processing time. The flow rate of milk is adjusted while installation, to meet the requirement of holding for 16 seconds in Holding section of pasteurizer.

Specifications are: 1) Process fluid, either milk or cream etc 2) Operating temperature, like HTST, or UHT 3) Flow capacity of process fluid and service fluids 4) Type of hot water generation system 5) Permanently installed or skid mounted 6) Instrumentation, type of recording of time-temperature, Controls like PID or SCADA.

Centrifugal Cream Separators: For production of toned milk (which has 3.0% fat), the fat has to be partially removed quickly from raw milk, which can vary from 3.5% (cow milk) to 7.0% (for buffalo milk) . To achieve this, Centrifugal Cream separators are used, which has number of angular discs mounted on a shaft, that is rotated manually (for smaller capacities of 60 lph) or with electric motor drive (for larger capacities 10,000 lph or more). The milk must be around 40 ^{o}C for efficient separation, so that minimum quantity of fat is left in skim milk, obtained after separation.

The types of cream separators may be open type (for small capacities) (**Fig.6**) or hermetically sealed triprocess machines (for larger capacities). The hermetically sealed triprocess machines (**Fig. 7**) can be used for 1) Clarification (just to remove dirt and extraneous material not in solution) 2) To separate fat completely and obtain cream and skim milk or 3) To standardize the outcoming milk to a suitable fat percentage (done either manual control of outlet or automatic systems). Among the hermetically sealed separators, Self-desludging types are available, which automatically remove the dirt (called clarifier sludge), without stopping the equipment for cleaning, making it possible for continuous operations.

Recent development is the use of centrifugal separation to remove bacteria present in milk, as a step towards, better quality milk to be used for manufacture of Ultra High Temperature (UHT) milk with long shelf-life at room temperature.

As, the separation is most efficient at warm temperatures, the Triprocess machines are usually linked to HTST pasteurizers, with outlets and return lines at suitable stages in Regeneration section of the pasteurizers. Hence, the capacities of separators and the pasteurizer must match, for smooth operations.

Specifications are: 1) Flow rate of fluid, 2) Warm milk or cold milk 3) Small capacity (below 60 lph), and if so, manual or powered or both 4) If large capacity, hermetic or self-desludging type 5) Duty, like clarification, separation, standardization (manual or automatic), Bactofugation 6) Connected to pasteurizer or individual.

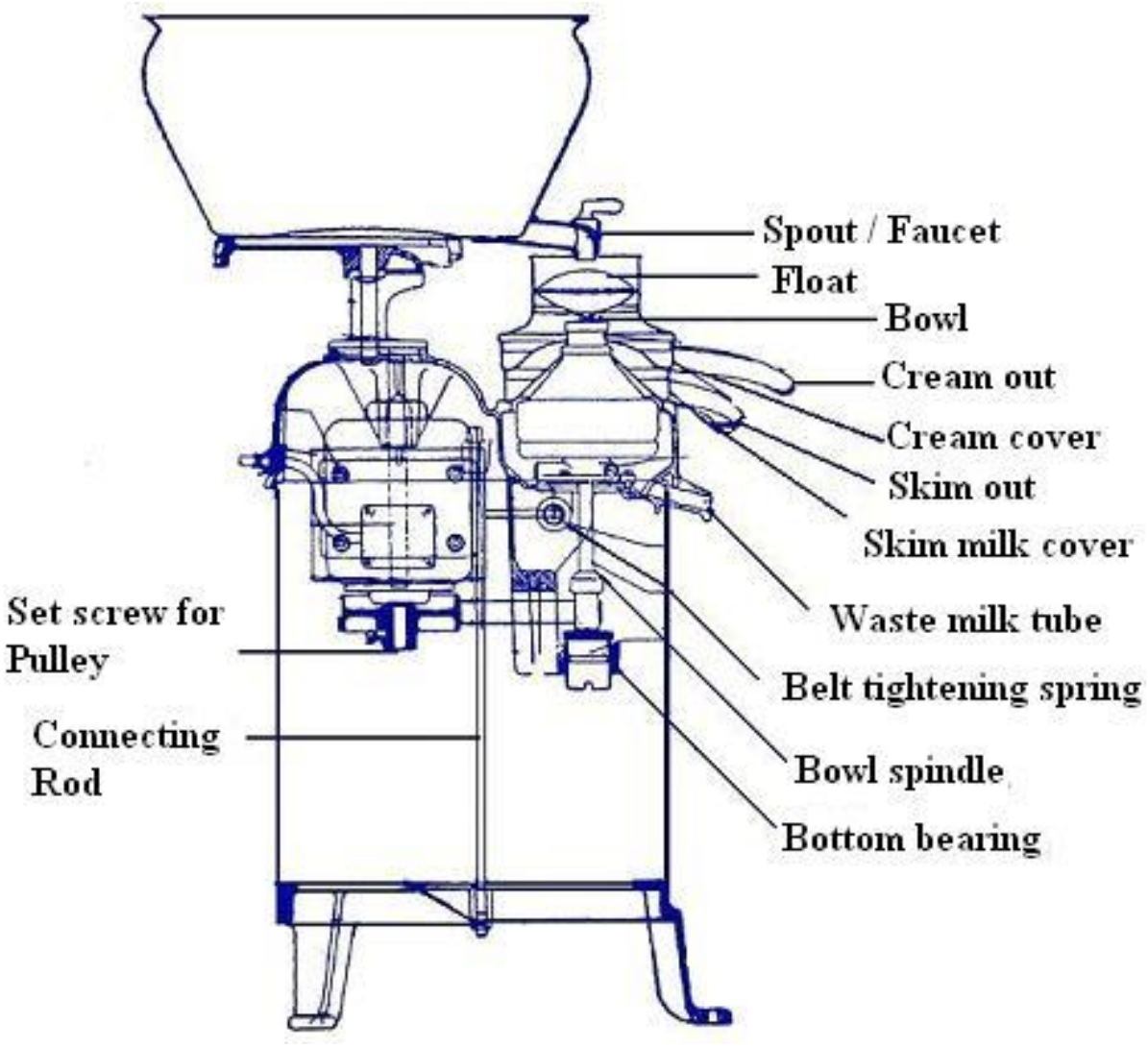


Fig. 6. Open type Cream Separator

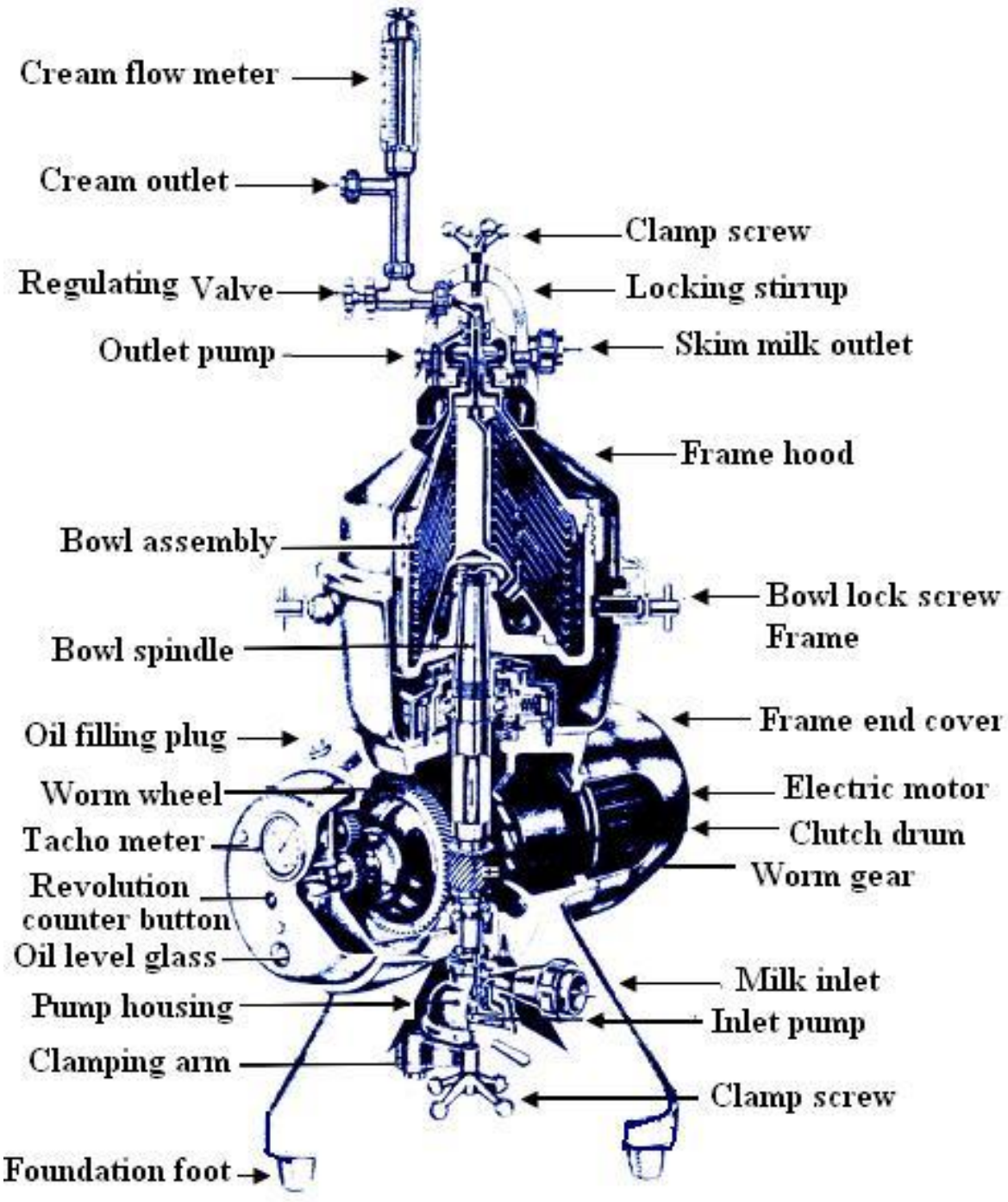


Fig. 7. Hermetic type Cream Separator

Homogenizers: With the requirement of long time storage, transportation and distribution of milk, there is a need of uniform distribution of fat in milk. This is achieved by reducing the fat globule size from 15 micron to less than 2 microns (which is 1/1000 th of a milli meter). This is achieved

by forcing milk through a narrow gap (called Homogenizer valve) under great pressure of around 175 kg/ cm^2 (nearly 2500 psi). For more uniform distribution of the broken fat globules, it is passed through a second stage at reduced pressure of 35 kg/cm^2 (about 500 psi), and finally passed into the outlet or to the subsequent processing. As this operation is most efficient around 55 to 60 ^oC, homogenizer is also linked to HTST pasteurizer at suitable outlet (usually after Regeneration section).

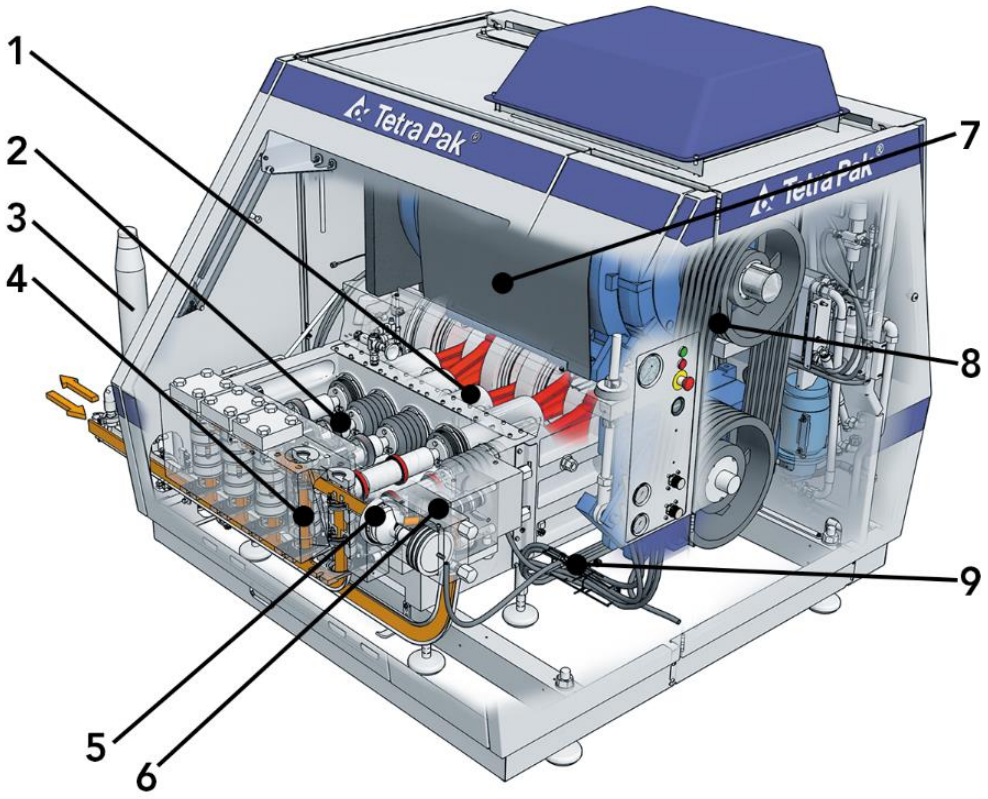


Fig. 8. Parts of Homogenizer

1. Crank case 2.pistons 3. Damper 4. Pump block 5. Homogenizer first stage valve
7. Homogenizer second stage valve 8. V- belt transmission; 9. Hydraulic pressure setting system

The Homogenizer (**Fig. 8**) basically has 3 or 5 piston- cylinders, mounted through connecting rods, on a common shaft, at an equal angle between them. The action of pistons draw milk through common header with suction and discharge valves. It results in discharge of the milk at high pressure into a common header. The arrangement results in lesser pulsations of suction and

discharge, so that efficiency of homogenization is not affected. The milk will lead from here to the Homogenizer valves, and after which it is discharged to the outlet pipeline. It is also recommended that an air cylinder each be fitted at suction line and discharge lines of homogenizer, to further reduce the pulsations of the pressures developed.

Homogenization is done not only for milk, but also to high fat products like Ice cream mix, before it is frozen, or for recombined milk, (made from mixing of skim milk with butter oil), for uniform mixing of fat.

Specifications are: 1) Single stage or two stage 2) Flow rate 3) Operating conditions like normal or Aseptic 4) Manual or pneumatic operation of valves 5) Number of cylinders :single(for small capacity), 3 or 5 cylinders.

Evaporators: The dairy industry works as a balancing wheel between the times of plenty of milk to times when milk is scarce. During flush season, ie. October to February, the surplus milk is converted to skim milk powder and butter. During lean season, ie. May to July, the milk is reconstituted from the skim milk powder and butter oil. The milk powder is made in stages, first, the milk is concentrated using evaporator, to about 50% total solids concentration. Then, the concentrated milk is made into powder using spray drier.

Evaporator, removes moisture in the milk, which is about 84%, to about 50%, under vacuum, so that the temperature of boiling is low. This will prevent damage to the protein and other heat sensitive components in the milk while concentration is increasing. The Evaporator may be batch or continuous type. The batch type is called Vacuum pan (**Fig. 9**). It essentially has a semi-cylindrical double jacketed vessel, with arrangement to evacuate the vapours formed and condense the same. A vacuum device is provided to create vacuum. The vessel is provided with agitator, pipe connections for loading the milk from side, and unload the concentrated milk from bottom. Controls will be provided to control the steam supply to the jacket and the degree of vacuum in the vessel. Provision is there for drawing sample from time to time to know concentration.

The continuous system of concentration (**Fig. 10**), is especially for larger capacity of production. The evaporator system has tall bundle of pipelines called Calandria, similar to shell and tube condensers, but positioned vertically. The milk is fed uniformly into the tube bundle from top. As

it flows down, it picks up heat from the steam surrounding the tubes, and vapours are formed. Both the concentrated milk and vapours flow down, from where the vapours are separated by Vapour separator chamber. To economically utilize the vapours from the vapour separator, it is drawn to the shell side of the next set of calandria, which is being operated at lower pressure. This results in a temperature difference between the vapours coming from first calandria and the milk getting evaporated in the tubes of second calandria. Though vapours travel from effect to effect, milk has to be pumped using pumps. In practice, 3 or more sets of calendria are operated in sequence, with decreasing operating temperatures from first calandria to the last. The rate of evaporation in each calandria and the degree of vacuum are carefully monitored for a continuous operation. The vapours from last vapour separator lead to a condenser, which uses water at ambient temperature, to condense the vapours.

Fig. 9. Vacuum Pan (Batch Evaporator) with Condenser and controls
(Courtesy: SVVU, Tirupati)

It is important that the milk from storage tank from 4^{o}C is initially brought to a high temperature of about 85^{o}C, through a series of heat exchangers, using vapours from each vapour separator, and

finally using live steam. Holding for few seconds at highest temperature is important to prevent spoilage and avoid gelation of the final concentrated milk (**Fig. 11**).

Specifications are tailor made to the applications, especially for 1)small scale or large scale 2)Final product, like Evaporated milk or Condensed milk 3) High heat or low heat 4) Number of effects 5) TVR or MVR for vapour recompression operation 6) Type of vacuum system, with fluids flow or mechanical 7) Types of condensing system: Barometric, contact or non-contact, 8) Types of cooling towers, forced draught of natural draught. As the larger plants involve more details, it is done, it is important that detailed project report is to be prepared.

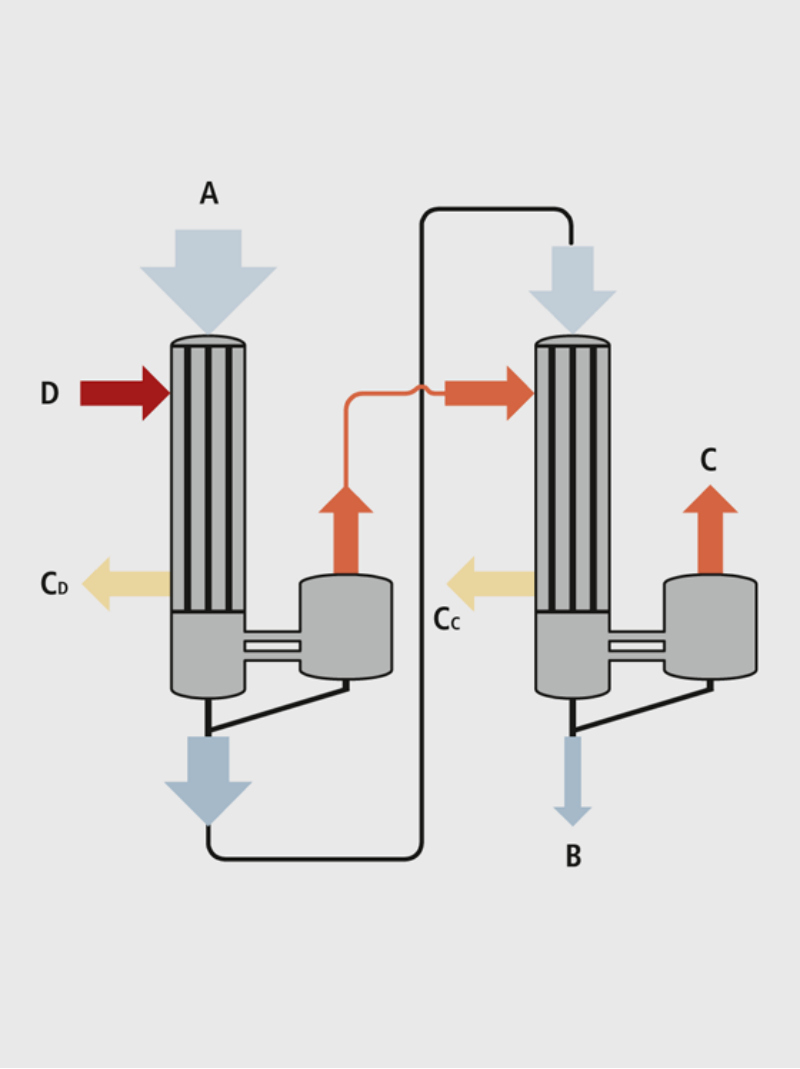


Fig. 10. Principle of Multiple Effect Evaporator (Source: GEA Mannual)
A= Milk; B = Concentrated Milk ; D= Steam; C_D, C_C – Condensates ; C= Vapour of last effect

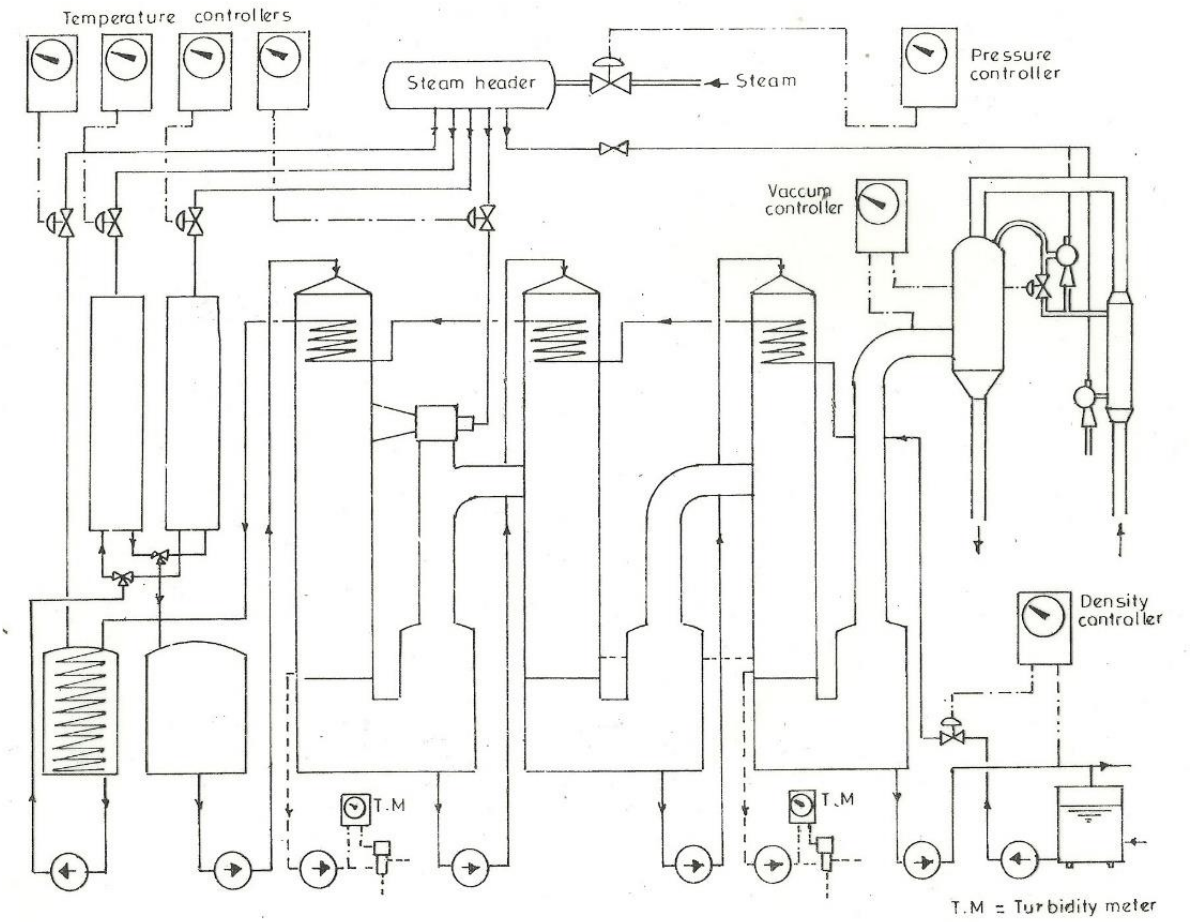


Fig. 11. Hook up diagram of Multiple effect evaporator

Specifications for Pipes and Fittings

Pipes and fittings form an important part of selection of equipment and involve significant costs of the dairy plant itself.

Pipes: The size of the pipe is most important specification, which depends on the process material and type to be handled.

Outside Dia. of Pipe (mm)	Approx. capacity (kg/h)
25	0 – 2000
38	800 – 7200
50	7200 – 15000
63	15000 – 22700
75	22700 – 36000

(i) Next larger size for heavy liquids, like cream, Ice cream mix.

ii) Similarly, next larger size if the flow is by gravity

iii) Criteria for selection is velocity of flow and cost

The pipes have to be internally pickled and mirror finish outside.

Connections: Commonly used methods for connecting pipes and fittings are flanged connections, welded fittings, and threaded couplings. The important aspect is that these should be not only effective, but also should be easy for cleaning and sterilization.

Flanged connections are used when the positions of the joining pipes are fixed, and do not change. They plate, forging or cast ring types, preferably of AISI 316L types of Stainless steel.

Welded fittings used only where there is no necessity to dismantle. They must be ground smooth, preferably Argon arc welded.

Threaded joints should be either SMS type for milk pipes or IDF types for CIP connections. The pipe connections should be such that with the help of swing bends, the connections can be changed according to the application, without much of dismantling.

Gaskets, which are essential to prevent leaks between pipes and fittings, should be able to withstand the temperatures and chemicals used for cleaning. Should not impart any flavour to the process liquid. The following are the types of gasket material and their tolerance for temperature.

1	Nitrile rubber (NBR)	130°C
2	Ethelene propylene (EPDM)	65°C
3	Silicone rubber	175°C
4	Viton rubber	180°C

Valves: The valves have to be of sanitary design. Most preferred is Plug valves and Butterfly valves for medium pressure operation. Pneumatically operated valves are used when automation is required, especially CIP and FDV.

Other fittings: Other important fittings, as per the requirement of pipe layout are Bends (45^o, 90^o, small or large), Joints (equal, reducer, co-centric or eccentric, "T") which may be flanged, threaded, clamped or Ring Joint type.

INSTALLATION:

The most important aspects in installation is to follow the manufacturer's instructions. The manufacturer may sometimes exclude some of the required items (like civil works, uninterrupted electric supply, facilities for unloading or hoisting) for the installation, trial run and commissioning. These have to be taken care of in time, so that installation is not delayed or incomplete. These sometime are legally time bound, in which case, the delay in provision for the installation should not be on promoter.

Important drawings of installation, manuals etc provided by manufacturer should be made in duplicate and a copy well preserved. The copies must be easily available while installation as well as regular operation of the equipment.

The installation must follow the general principles of plant layout.

If the technology of equipment is new, unique, then it must be insisted on training of the actual personnel who are going to operate it.

The installation of a particular equipment or group of equipment must be coordinated with the Project development and Project management.

*****

Dairy Processing Utility Equipment: Selection, Specifications and Installation

J.K. Dabas
Chief Technical Officer & In-Charge, Maintenance Engineering Section
ICAR-National Dairy Research Institute, Karnal

REFRIGERATION SYSTEM AND COLD STORAGE

Introduction:

Refrigeration is an integral part and one of the most important utility of a dairy processing unit. We know that all the dairy products including the raw product milk are perishable in nature and have short life span, if stored at normal temperature. However, by sharing these products at a lower temperature or in refrigerated condition their life span can be considerably increased. In fact due to refrigeration only, the commercial processing of milk and production of dairy products and their marketing has become possible. Due to refrigerated conditions maintained during storage and transportation, we get packed milk and dairy products in almost fresh condition even when it is produced or procured days before and at some distant place. Not only this, refrigeration is also a part of production process in case of dairy products which are procured and consumed in refrigerated condition like ice cream, frozen desserts etc.

In this way, refrigeration equipment like walk-in-cooler, cold room, chiller, ice cream freezer, deep freezer etc.come in the prime requirement of a dairy processing unit. One more thing here to note about is that in general a refrigeration system consumes a considerable part of total electric energy consumption of the whole processing unit, sometimes may be up to 50% of total electricity consumption. Likewise, the initial cost of the refrigeration system is also on higher side and it is a considerable component of the total cost of processing plant Therefore, it become necessary to select and specify the right type, size and capacity of the refrigeration system or equipment by correct assessment of the total cooling load and refrigeration requirement suitable to processing unit by any qualified expert. Wrong choice in terms of under or over capacity, design & type, position or location in the plant or many other factors would lead to increased production or processing cost and decrease the competitiveness of the establishment.

Refrigeration System Working and Components

Principle of Working:

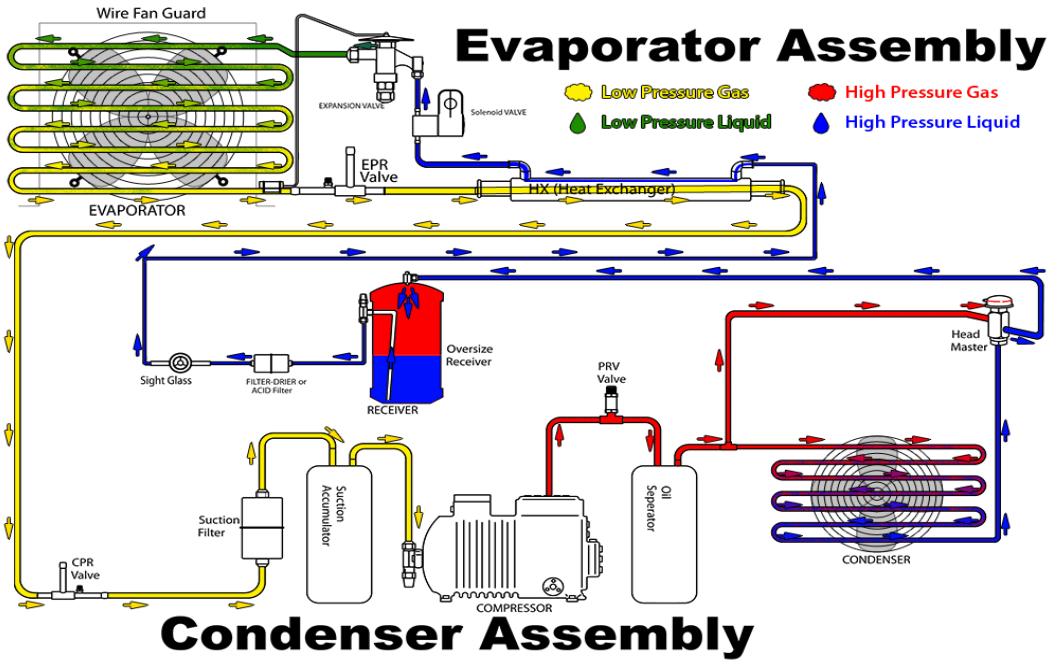


Fig.1 Vapour Compression Refrigeration System

Most of the Refrigeration Systems small or large capacity work on the principle of Vapors Compression where the refrigerant vapors are compassed by a motorized compressor to increase pressure and temperature and discharged to any type of condenser or Led exchanger, where high pressure and high temperature vapours reject heat to the cooling air or water and condense to high pressure liquid. From the condenser this high pressure liquid then flows to an expansion valve or throttling valve which reduces its pressure and so temperature by partial evaporation. It is a thermodynamic principle that when a closed system the pressure of saturated liquid is is decreased its saturation temperature (boiling point) also reduces due to which a part of liquid gets evaporated taking heat from remaining liquid thus cooling it. The reduction in temperature is directly proportional to reduction in pressure while passing through expansion valve or throttling valve which offers flow resistance and thus reduces the pressure. After expansion valve, this low temperature and low pressure liquid is then passed on to another heat exchanger called evaporator situated in refrigeration space. Due to lower temperature, the refrigerant liquid absorbs heat from refrigeration space through the evaporator tubes and continuously converts to vapour. The heat absorbed in this way has higher valve because it is latent heat and so a small amount of refrigerant liquid flow through evaporator produces a higher amount of cold or refrigeration. After the

evaporator, the low pressure and low temperature refrigeration vapour are again sucked by the compressor thus completing the cycle. In this way when the refrigeration unit is switched on the compressor motor runs the compressor and the flow of refrigerant filled inside the closed system starts and so the cooling happens in the refrigerated space. A simple diagram showing all the four components of a typical refrigeration & system is shown in the Fig. 1.

Refrigeration Components and their different types

1) Compressor
   i) Rotary Compressor (Used in small refrigeration equipment like Domestic Refrigerator and ACs)
   ii) Reciprocating Compressor (Used in small to medium refrigeration application)
   iii) Screw Compressor (Used in large refrigeration application)
   iv) Scroll Compressor (Used in small to medium refrigeration application)
   v) Centrifuges Compressor (Used in medium to large refrigeration application)

Their further sub-types based on position of electric motor and drive are

   a) Hermetically sealed (Motor and Compressor in one sealed casing: used in small equipment like Refrigerator Compressor)
   b) Semi-Hermetic (Motor and compressor are sealed together in one casing but more ease of access for maintenance purpose)
   c) Open type (Motor and compressor are separate and can be maintained separately)

2) Condenser

It is a type of heat exchanger where the refrigerant flows on one side and air or water on the other. Its different types are:

   i) Air Cooled (Naturally cooled or fan cooled)
   ii) Water Cooled
   iii) Evaporator Type

Further Sub types are

   a) Tabular heat exchanger with wire fins (Air cooled condenser of a domestic refrigerator)
   b) Plate fins type tubular heat exchanger (Air cooled condenser of small or medium systems)
   c) Shell and tube heat exchanger (Water cooled condenser of large refrigeration plants
   d) Plate heat exchanger (Water cooled condenser of medium size system)
   e) Bare tube condenser (Evaporative condenser of medium to large applications)

3) Evaporator

It is also a type of heat exchanger where refrigerant flow through the inside of tubes and outside is refrigerated space or any heat carrying fluid named as secondary refrigerant. Its different types are:

i) Dry Expansion Evaporator (Used in case of Freon Refrigerants)
ii) Flooded Evaporator (Used in case of Ammonia Refrigerant)

Further Sub-types are

a) Bare tube bundle (As in case of domestic refrigerator the refrigerant tubes are wrapped around freezer box)
b) Corrugated Plate Evaporators (In case of modern refrigerator)
c) Dimple Jacket Evaporator (Generally used in BMC)
d) Brazed tubes on Plate (Water Cooler)
e) Plate Finned Tubular Evaporator (Used in medium to large applications)
f) Bare tube submerged Evaporator (Used in Ice Bank Tank)

4) Expansion Valves:

It offers flow resistance while passing the refrigerant through a narrow restriction thus decreasing its pressure and temperature. Its different types are:

i) Capillary Tube (Simple narrow diameter copper tube used in small rating refrigeration systems like domestic refrigerator or AC's etc.)
ii) Thermostatic Expansion Valve (Used with dry expansion evaporator as in case of Freon Refrigerants)
iii) Float Valve (Used with flooded evaporator as in case of Ammonia in large size refrigeration plant)
iv) Manual or Electronically Controlled Valve (Also used in large capacity Ammonia refrigeration plants)

5) Refrigerant:-

It is not a physical component of the system but it is the fluid which flows through each component and undergoes thermodynamic changes and absorbs heat through evaporator thus produces refrigeration effect. Its properties not only affect the performance of system but it also has influence on our environment and safety in case of leakage or end of life cycle of system. Its selection is vital while designing a new refrigeration system as it should fulfill the following requirement.

a) Good performance in terms of power consumption per ton of refrigerator capacity
b) It should be safe, non-flammable and non-toxic and non-reacting to human, material and environment

c) It should not be in the category of phased out refrigerants or to be phased out refrigerants in near future due to environmental reasons like high global warming potential (GWP) and or high ozone depletion potential (ODP)
d) It should be cheap and easily available.

6) Insulated Refrigerated space (Cold Room)

It is also a main part of the complete Refrigeration Plant or System. It is an insulated cabinet or chamber or tank or small to large size cold storage where the evaporator of refrigeration system is installed and the products which are to be cooled or refrigerated are stored inside. Here Insulation material layers are provided on all the sides including door so that the coldness of inside space is maintained and natural heat flow from hot ambient conditions outside to cold refrigerated condition inside is prevented.

Insulation materials are those materials which have very low thermal conductivity value or very high thermal resistance due to their porous nature and air space in between. Some commonly used insulation materials are glass wool, thermocol, PUF, XPS, EPS etc. Nowadays PUF panels of various thickness and sizes are very commonly used either directly to form insulated cabinet or fixed as insulation on the inside surface of brick-cement walls of cold storage. There panels have all the required characteristics like high thermal resistance (R-value), moisture resistant, non-flammability, excellent building strength and easy to use or install.

The selection of right kind of insulation material, its optimum thickness depending upon temperature deference between inside and outside, required compressive strength and cost are very important while designing a cold room or refrigeration facility. Undersize insulation would result in continuous loss of cooling and increased operational cost. Over sized insulation would lead to high initial cost.

Capacity and Performance of Refrigeration System

Refrigeration Capacity:

It is the rate of heat extraction by the evaporator unit of refrigeration system from the refrigeration space. It can be expressed in Kcal/ min or KJ/ min or KJ/ S (KW). However, its commercial unit is Tons of Refrigeration.

Tons of Refrigeration (TR):

One TR is equal to the heat extraction rate which would be capable of converting one US Ton (908 Kg) of water at 0ºC into ice at 0 ºC in 24 hours. Mathematically, it is expressed as:

1 TR = 50 Kcal / min
Or 1 TR = 211 KJ / min
Or 1 TR = 3.51 KW

Power Consumption:

The power input of Refrigeration system is mainly the power consumption by compressor. However, some auxiliary equipment like condenser and evaporator fans or circulation pumps of condenser, cooling tower etc also consumes a considerable power.

COP /EER

It is defined as the ratio of Refrigeration capacity to the Power Consumption. Higher COP/ EER valve means better performance. It is always looked into while selecting a Refrigeration System.

Important Points considered for the Design, Selection and Installation of Refrigeration Utility

1. Identification of different kinds of cooling requirements in the Dairy Processing Unit.
2. Correct estimation of cooling load in TR for each of the cooling requirements considering all the heat loads alongwith product cooling load in terms of temperature change per unit time. For cold rooms cooling load is generally calculated on 24-hr basis
3. Cooling load variation during 24 hrs and also between different seasons throughout the year needs to be assessed correctly to decide the maximum refrigeration capacity and type & amount of capacity control of refrigeration system. Cooling storage in terms of ice bank tank is an option commonly used in dairy plants. With storage options, refrigeration system need not to be selected on the basis of peak requirement at a particular time.
4. In case of cold room, insulation is kept in mind while calculating natural heat flow from outside through walls, roof and floor. Insulation is designed based on its characteristics and

the requirement regarding R-value, compressive strength, moisture resistance, non-flammability etc.

5. Type of Refrigerant is the primary parameter to be decided keeping in mind the performance, safety, its environmental restrictions, cost & availability etc.
6. Type of compressor, condenser & evaporator and expansion valve. Selection of type of compressor is most important in terms of performance characteristics matching with requirement, maintenance issues, initial and operational cost, reliability & life cycle etc.
7. Proper location of cold storages in the processing plant and each of the refrigeration components is also very important. Cold storage is located within the plant to avoid direct sun exposure of the walls or roof as far as possible and taking care of easiness in loading and unloading of products.

   Small capacity refrigeration units come in two split units as the condensing unit (compressor & condenser) and evaporator unit (evaporator & EV). Condensing unit is also called outdoor unit and located outside the cold room in open. It should be located in the airy space and should not be in the direct exposure of Sun so that it may easily reject heat to the atmosphere. Likewise the evaporator units are located inside the cold room keeping mind uniform distribution of cold air in all the space without flow restrictions. In larger cold rooms however air ducts are used for this purpose.

   As far as possible the condensing unit and evaporator unit should not be far from each other. Otherwise the performance will decrease and the piping & refrigerant cost would increase.
8. Intelligent control of the refrigeration system through modern instrumentation is very important. Various automatic controls options are available like: precise temperature control, on-off control, defrosts control, compressor capacity control, evaporator fan speed control etc. The automatic controls enhance the performance, safety and life of system. However extra cost is involved but still a well controlled system always offers better overall economy.

STEAM GENERATION, SUPPLY AND SELECTION OF BOILERS

Introduction:

Boiler is another important utility of a dairy processing plant which meets all the heating requirements of the plant. We know the application of heating or cooking is an important process in the overall procedure of processing of milk and milk products. Heating is primarily produced

by burning of any fuel like wood, coal, oil and gas etc. In our homes and at small scale production units like at halwai shops the milk and milk products are heated in pans/ vats placed directly over fuel burners or furnaces where fuel is burnt. But the fuel burnt always produces hot flue gases/ smoke which escapes at the same place after giving useful heat to the product vats. Burning of fuel at the same place of cooking inside the plant produces unhygienic and polluted conditions which are not allowed and feasible also in a commercial dairy processing plant. The solution to this problem is given by Industrial Boilers and steam systems. The boiler is installed in boiler house adjacent to the main processing plant building. The job of boiler is to burn the fuel and transfer its heat to water to convert into steam. The steam carries a large amount of heat due to higher latent heat of water and is very neat and clean medium to carry this heat in the processing plant where it is needed to transfer it to milk and milk products. In this way fuel is burnt in the boiler far away from the processing point and pure heat in the form of steam is given to milk and milk products through steam jacketed vats/ vessels or heat exchangers. In the boiler, fuel is also burnt very efficiently and its heat is efficiently transferred to the water/ steam. The benefit of using steam as heating medium is not only maintenance of proper hygiene and cleanliness but it also gives easy handling and a better control over the heating process. With the use of pneumatic steam control valves, automatic thermal control to ensure better product quality is possible. Thus generation of steam in a commercial boiler and its distribution in the processing plant through insulated steam pipes and fitting is universally adopted in all the dairy and food processing plant. In the boilers also a heavy initial cost and operational cost is involved and so its selection on the basis of higher performance or efficiency and also long reliable life cycle is very important. Wrong choice may result into unavoidable losses.

Boiler and Steam System Working

Boiler is a type of heat exchanger mostly shell and tube type, where hot flue gases remains on one side of the boiler tubes and water remains on the other side. On this basis Boilers are classified as Fire tube Boiler and Water tube Boiler. In a Fire tube boiler, flue gases pass through the tubes and water remains stored outside the tubes within the shell. The hot tubes remain submerged in the water and transfer heat to water at a faster rate due to large contact area and heat transfer coefficient. On getting heat, steam is formed and accumulates at higher pressure in the steam space of the shell at the top from where it is moved to the plant through steam's main pipe and the flow

is controlled through a steam stop valve. Due to higher pressure of steam in the boiler, it moves to the point of use on its own through steam distribution piping system. The flue gases are generated in the boiler furnace or burner in case of oil/ gas fired boiler and then after passing two three times through the tube bundle and handing over major portion of their heat content to the water, finally escapes to atmosphere through chimney. In case of water tube boiler fire remains in the shell and water flows through the tubes. Water tube boilers generates steam at very higher pressure and used in the power plants for running of turbines. In a dairy/ food processing plant fire tube boiler is generally used which generates low pressure steam which suits to the requirement of using steam only as a heating medium and not to generate mechanical power. A typical coal fired boiler is shown in the figure 2.

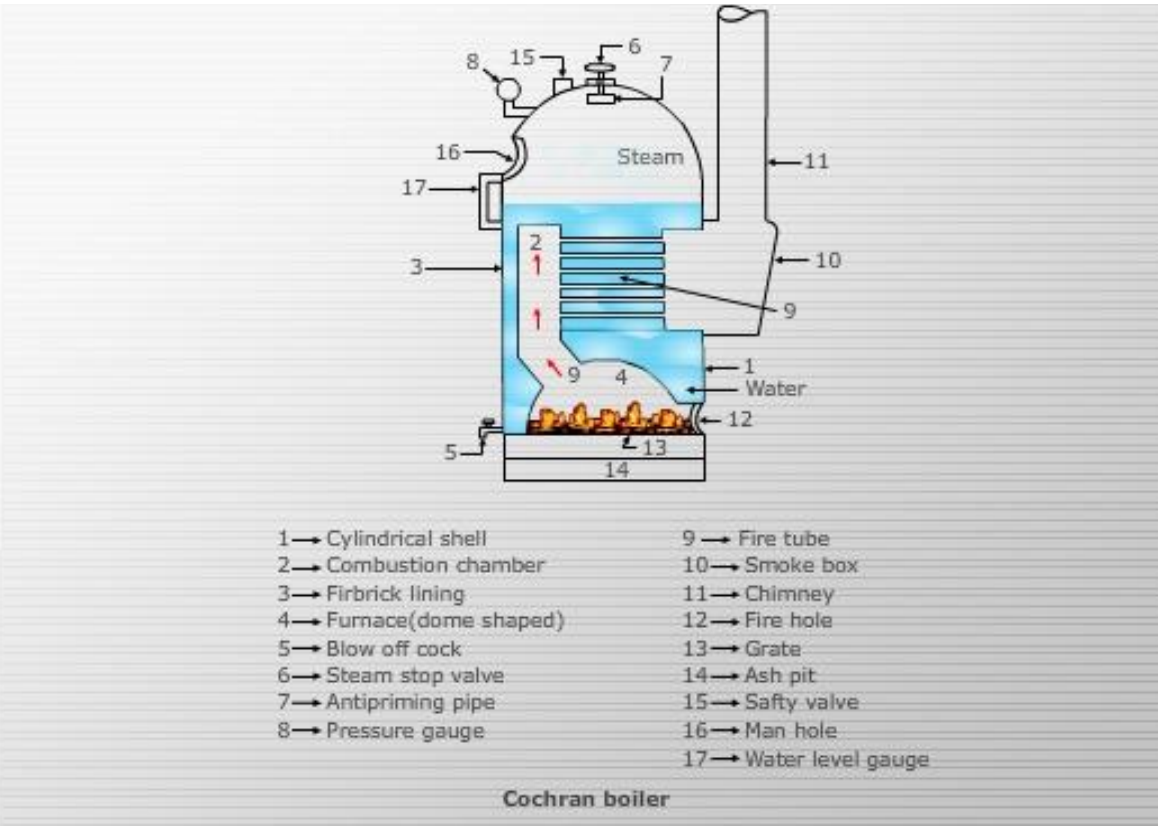


Fig 2. Cochran boiler

Boiler Mountings

Various fittings on the boiler like pressure gauge, safety valves etc which are necessary for its safe and efficient operation are called Boiler Mountings. Various boiler mountings are:

(i) Water Level Indicator (To check the water level in the boiler shell manually)

(ii) Pressure gauge (To indicate pressure of steam in the boiler)

(iii) Safety Valve (To release steam automatically in case steam pressure exceeds the limit for the safety of boiler)

(iv) Fusible Plug (Located inside the boiler and melts itself in case the tubes are overheated due to low level of water in the boiler)

(v) Blow off Cock (To blow down some of the water from boiler intermittently to keep control over TDS and safety of the boiler)

(vi) Feed Check Valve (Type of non return valve fitted at the feed water inlet. It allow water to go inside the boiler but prevent steam to come out)

(vii) Steam Stop Valve (Fitted at the steam outlet for flow control of steam)

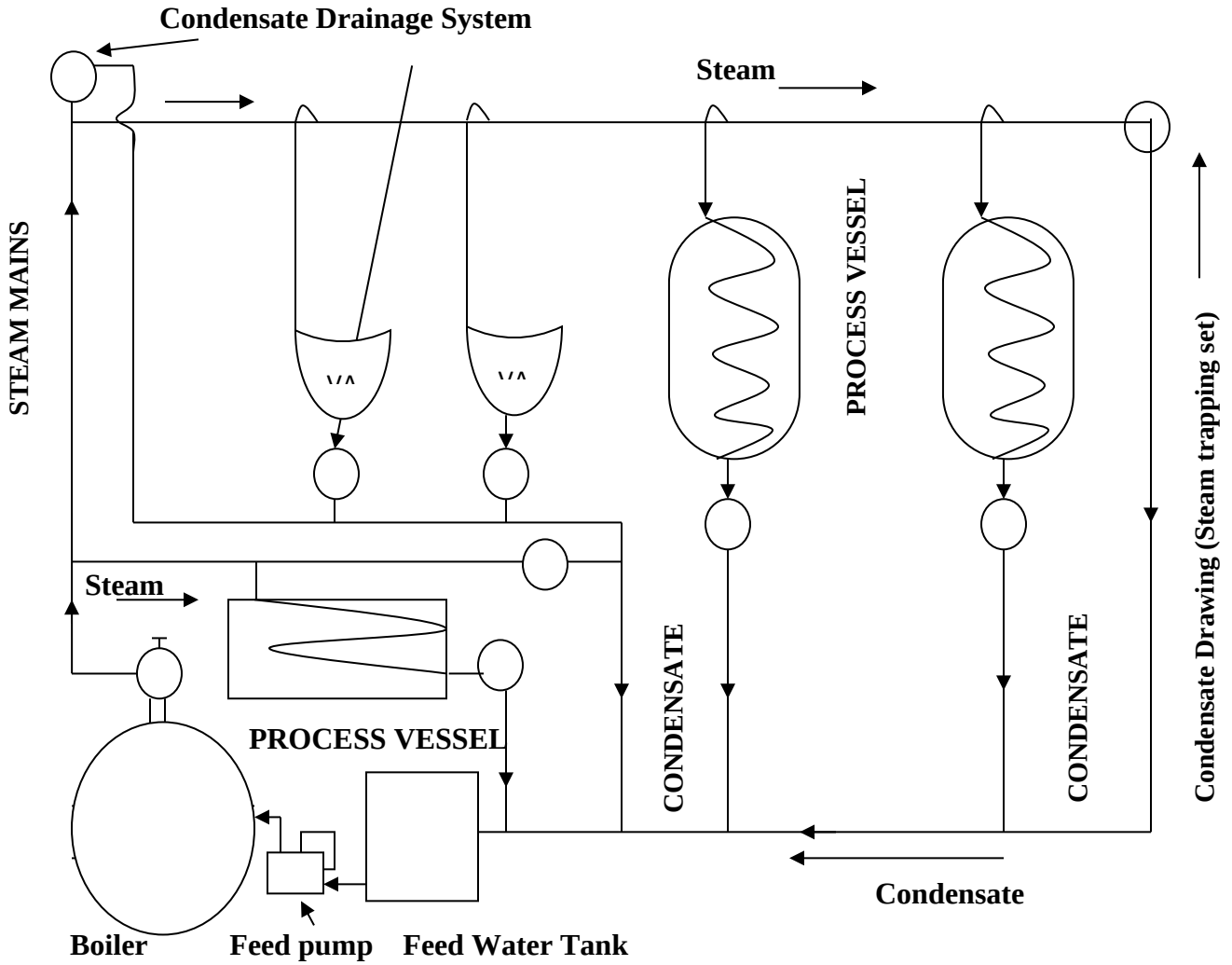


Fig. 3. Basic Steam Pipe Circuit

Boiler Accessories:

The integral parts of boiler which are required to enhance its efficiency or for overall performance are called accessories e.g. Feed Pump, super heater, economizer, feed pump, air preheater etc.

(i) Feed Pump (A high pressure pump to pump feed water against high pressure inside the boiler vessel)

(ii) Economizer/ Water pre-heater (preheast the feed water by outgoing flue gases thus increases the boiler efficiency)

(iii) Air-Preheater (preheats the incoming air used in fuel combustion by outgoing flue gases thus increases the combustion efficiency)

Steam Distribution System:

The steam is generated in the boiler and then flows to various process vessels through insulated steam pipe network as shown in Fig.3. After giving its heat to the products it converts to condensate and come out of the jacket through steam trap. Function of steam trap is to throw out condensate formed but trap the steam inside. In an efficient system, this condensate is recovered back to boiler feed water tank thus saving of heat energy as well as precious soft water. Some other essential fittings are also used in the piping system as shown in Fig.4.

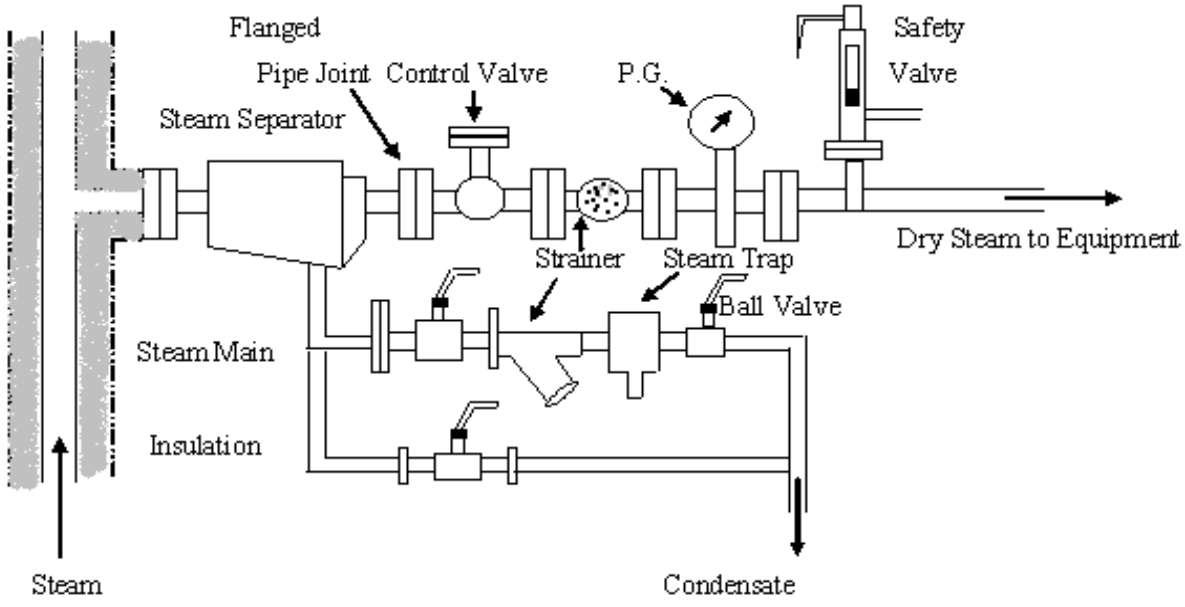


Fig 4. Steam Pipe Line Fittings

Indian boiler regulation act

Objectives of Indian Boiler Regulation Act

Indian Boiler Regulation act is made to encompass the following

1. Provide for the safety of life, limb and property.
2. Create a board for boiler rules to serve the society.
3. Formulate rules and regulations for the safe and proper construction, installation, repair, use and operation of boilers and unfired pressure vessel.
4. Provide for the examination and appointment of boiler inspectors.
5. Provide for the inspection of boiler and unfired pressure vessel, the fees to be charged and the reports to be made thereof.
6. Provide for the enforcement of the rules and regulations promulgated by the board of boiler rules.
7. Provide for inspection certificate.
8. Provide for appeals.
9. Provide a penalty for the violation of the provisions of the act.

The boiler being pressure vessel is required to be operated within safe pressure limits with regular checkup and maintenance, because the failure of a boiler may prove extremely disastrous. To ensure full safety, some standard rules and regulations have been enforced through legislation, all over the country. This is known as Indian Boiler Act 1923. All boilers owners are required to follow this legislation in a strict sense.

Performance of Boilers

Boiler Capacity in terms of Equivalent evaporation

It is defined as the weight of saturated water at 100°C evaporated to dry and saturated steam at 100°C by utilizing heat at the same rate as would have been used under the actual working conditions. It is generally expressed in terms of tons/hr. For example One ton boiler means its equivalent evaporation at full capacity is 1000 kg of steam per hour.

Factor of evaporation

It is a quantity which when multiplied by the actual amount of steam generated at a given pressure from water at given temperature, gives the equivalent evaporation.

Equivalent Evaporation = F x Actual Evaporation

Thus factor of evaporation may also be defined as ratio of Equivalent Evaporation to actual Evaporation.

Boiler efficiency

It is the ratio of heat actually utilized in generation of steam in a given period to the heat supplied by fuel in the same period or it is the ratio of heat utilized in generation of a given quantity of steam to the heat supplied by fuel burnt to produce this steam.

$$\text{Boiler Efficiency, } \eta_b = \frac{W_a(H - H_{w1})}{W_f . C}$$

Where, Wa = steam generation rate(kg/ hr); H= specific enthalpy (heat content) of steam produced (kJ/ kg), Hw = specific enthalpy (heat content) of feed water (kJ/ kg); C = calorific value of fuel in kJ/kg and W_f = weight of fuel per hour.

Boiler efficiency is always less than 100% because of some loss of heat through hot gases escaping to atmosphere and also directly to atmosphere by conduction convection and radiation.

Important Points considered for the Design, Selection and Installation of Boiler

1. Identification of different kinds of heating requirements in the Dairy Processing Unit.
2. Correct estimation of total rate of heating required and temperature to be maintained in all the vats, process vessels/ equipment, CIP etc. based on the amount of products their sensible/ latent heat and temperature/ concentration change and possible losses.
3. Correct estimation of steam consumption rate and steam pressure throughout the day based on total heating rate and all kinds of steam distribution losses and pressure losses through steam distribution system. The maximum steam consumption rate multiplied by factor of evaporation should not be more than 80 % of the Boiler steam generation capacity and likewise the maximum pressure requirement should be well below the safe working pressure of the boiler. Little overcapacity of the Boiler may be selected keeping in mind the future requirement.
4. To meet the excessively varying load two Boilers may be selected so that when both working meet the peak steam requirement and only one can be run at reduced steam load.
5. A boiler is primarily specified by the type of fuel used i.e. coal fired, oil fired or gas boiler etc. The selection is based on various aspects like fuel cost per unit of steam production, it's

easy availability in a given location, environmental/ pollution restrictions, fuel storage space and handling facility available in the processing plant.

6. Boiler efficiency is also an important parameter to be looked into while selecting a boiler and its accessories responsible for efficiency improvement like air pre-heater, economizer, super-heater.
7. PLC control of the working of Boiler system further ensures best thermal efficiency by improved combustion efficiency, improved safety, life and reliability of boiler and hence decreased operational cost and fulfillment of environmental norms by effectively controlling various operational parameters such as excess air through speed control of FD fan, outgoing flue gas temperature, concentration of CO, O2 and other polluting gases in the outgoing flue gases, TDS of boiler water through automatic blow down control, steam pressure, water level etc. However, decision is taken on the basis of overall economy. Any additional expenditure on the improved efficiency is done on the basis of payback period.

*****

Dairy Plant layout

Ankit Deep

Scientist, Dairy Engineering Division, ICAR-National Dairy Research Institute, Karnal

1 Introduction

Since India is the leading country in milk production in the world at a fast rate, it has led to a need of very scientific layout and planning for the dairies being set up by the dairy designers, engineers and architects. In some organized sectors, milk collection and chilling of milk is done, before it is transported for processing at dairy factory. The dairy technology commences with processing of milk at dairy plant for market milk and various dairy products. The dairy plant layout and design means designing a layout plan for dairy plant. i.e layout of various sections in dairy building, equipment layout, laying of dairy machines in each section for economical and efficient movement of men and material in the plant.

Dairy Plant design, involves the estimation of capacity, process scheduling and proper layout so as to achieve the objective of handling milk at the least cost and greatest safety. However, the dairy industry and the plant design has to meet certain special requirements and need to be focused on these.

It is very difficult to develop perfect plant layout for all categories of equipment and services. The ideas of several persons are usually required to make a planning of a dairy building. The provision of future requirements is also to be considered as far as possible. It is noticed in many plants that it is not possible to install a single HTST plant in the existing building to handle more milk. Therefore, it is necessary to consider additional capacity requirement for the next 5-7 years. The adequate provision for offices, laboratory, storage etc. is one of the essential requirements in the planning of dairy plant. The dairy plant layout involves room arrangements and equipment layout considering all technical aspects.

The elevation of dairy building should give advertising image to the people. The form and shape of dairy building is important as it affects the public reaction as well as upkeep and initial cost. In addition to several technical considerations, marketing of dairy products needs good site selection and attractive building design. Appearance and look are the primary factors affecting the marketing

of the products. If a brand is having a typical pattern of building replicated at many places the building pattern itself may become identification for the brand of the organization.

2 Space requirements for dairy plant

The space requirement for dairy plant should be estimated for its functional design to have smooth operation. The space requirement of entire dairy plant is estimated by adopting principles of dairy plant layout. It is a basic requirement to estimate the total area required for the dairy plant which include building area, parking, movement of vehicles, roads, ETP etc. The type of layout varies considerably for the same plant after having estimated the space and area requirements for different sections. Land requirement is one of the basic cost factors of the plant and land cost has increased considerably in last decades. Therefore, it is important to design the plant with cost effectiveness. According to size and shape of the plot, the most befitting type of layout is selected and all sections are planned in accordance requirements.

2.1 Area and space requirements for milk plants

Space required for equipment depends upon the capacity and dimensions of the equipment. There is no any rigid rule to decide the area of various sections. It mainly depends on the idea and judgment of engineer who is designing the dairy plant. General guidelines are given below to estimate the size of different sections.

Table 1: Approximate area and space requirements for dairy equipment

Milk reception dock (single conveyer and weighing pan)	7 m x 10 to 14 m
Can washer	5m x 5 m (rotary can washer), 5m x 20 to 22 m
Horizontal milk tank, 10,000 litres	3m x 5m
Horizontal milk tank, 20,000 litres	4m x 7 m
Vertical tank, 10,000 litres	4m x 4 m
Process room area, minimum	5-6 times the area of equipment
HTST pasteurizer, 10,000 litres/h	25-30 m^2
Space between two equipment	1-1.5 m
Space between two tanks	1 m
Area of small dairy. 10,000 to 15,000 litres/day	200 m^2
Area of medium size dairy. 40,000 to 50,000 litres/day	300-400 m^2
Area of larger size dairy. 50,000 to 100,000 litres/day	400-600 m^2

Note: For higher rates, equipment will have to be duplicated and into 60% extra space must be allowed.

2.2 Space requirement for different sections of dairy plant:

Allotment of the space for the specific section and to the specific plant and equipment is a matter of thinking so as to provide sufficient space to each plant and equipment for better functioning at the place for worker. Less space will create congested atmosphere and may cause accident at work in hurry some time; whereas unnecessarily providing more space may cause shortage of land in future and will cost more for maintaining cleanliness. So, the space provided for a section should be sufficient enough for working freely and comfortably, which should be planned well with concept of expansion in future also. The sections like boiler, electricity and refrigeration should be kept in isolated area to safe guard the plant from accident and damages. The decisive factors which are to be kept in mind during construction of plant for space are (i) Size and the capacity of the equipment i.e. height, length, width, etc. (ii) Type of operations to be carried out (iii) Future expansion.

3 Estimation of service requirements including peak load consideration

Estimation of service requirements is important to determine the capacity of equipments used for providing different services in the dairy plants. The major utilities of dairy plants are steam, refrigeration, electricity and air supply. It is necessary to know rate input services required for various equipments. The peak load can be estimated by for various services based on the operating schedule of the equipments. The peak load estimation is also important to make contract for connected electrical load of the dairy. The peak load requirement for steam, refrigeration, electricity and effluent treatment plant is very much necessary. Peak load is calculated based on capacity utilization of equipment and load conditions of cold store, ice bank tank and effluent treatment plant. Dairy processing plants are traditionally divided into two separate categories for the purpose of production and energy statistical data presentation: fluid milk; and industrial milk. These two categories are described as follows:

Fluid milk processing involves the pasteurization and processing of liquid milk for direct consumption, as well as creams, chocolate and other flavoured milks, and buttermilk.

Industrial milk processing involves the processing of milk into value-added products. These include cheese, butter, ice cream and other frozen products, condensed and evaporated milk, dried

milk powder, yogurt and other cultured milk products. The milk used in the manufacture of industrial milk products is also pasteurized before processing.

For the purpose of this guide, seven major generic process sequences (one fluid and six industrial) have been considered. These processes are (i) Fluid milk; (ii) Cultured products; (iii) Cheese; (iv) Butter; (v) Ice cream and other frozen products; (vi) Evaporated/dried products (vii) Traditional Indian dairy product.

These generic process/product combinations were selected because they:

- Cover the wide range of product manufacturing activities undertaken;
- Represent the natural groupings of similar generic processes; and
- Coincide with the general process categories separately modelled in support of Hazard Analysis Critical Control Points (HACCP).

3.1 Steam Requirement

Steam requirement is calculated for processing and other purposes separately, while boiler for condensing and drying plant is selected separately, based on the calculation of steam requirement in the condensing and drying plants. After estimation of steam requirement of each equipment on hourly bases, time schedule diagram including each processing equipment is prepared to know the peak requirement of steam in the peak hours. Depending on the peak load requirements, steam pressure is maintained and boiler is started in advance to get required steam pressure and quantity of steam. The main steam line pressure is maintained higher than actually required during peak load hours, considering losses in the lines and number of bends in the line. The fluid milk plant requires approx. 0.25 to 0.4 kg of steam per litre of milk, while that of powder plant requires approx. 5 kg of steam per kg powder.

3.2 Refrigeration Requirement

Refrigeration requirement of dairy plant is mainly divided into two major categories (i) Chilling load and (ii) Cold storage load. Chilling load is referred to the chilled water requirement of different equipments during processing of different products. It is calculated based on the chilling requirement of different processes. The chilled water requirement of different processes can be met by Ice Bank Tank (IBT) or Ice Silo. IBT can be designed based on the total requirement of chilled water in the different processes in a day. The refrigeration plant for IBT can be operated

during night hours (16 to 18 hours a day). The cold storages are required for different dairy products like ice cream, butter, cheese, milk etc. They are maintained at different temperatures and at different relative humidity depending on type of product to be stored. The cold storage refrigeration plant capacity is calculated based on consideration of different types of loads like product load, wall gain load, air change load, lighting load and miscellaneous load.

Time schedule for different processes which, requires chilled water is prepared to know peak load requirement of chilled water. Similarly, time schedule for loading and unloading of the cold storages are also prepared to know peak load requirement of cold storages and accordingly refrigeration plant is operated to conserve energy.

3.3 Electricity Requirement

Electricity requirement for different equipments, pumps, motors, refrigeration plants, lighting and general purpose is calculated based on actual operating load. Depending on the requirement of single phase and three phase connections load distribution is made using necessary controls. All the equipments are provided with safety devices to protect from over load condition or voltage fluctuations. Motors are provided with variable frequency drives and soft starters to conserve energy. Refrigeration plant of dairy contributes approx. 40 to 50% of total electricity load.

3.4 Water Requirement

Water supply for dairy plant is important and must be considered at the planning stage. An adequate supply of pure water for washing of equipment and cooling purpose is essential. An ideal water supply is one that is soft cold and free from all impurities. The water is treated to meet plant requirement by using suitable process. The hardness of the water used in the dairy plant should be maintained below 35 ppm. Generally, the ratio of milk:water of fluid milk plant is 1:1, while that of multi product plant is 1:1.5 or 1:2. It depends on type of products made and size of the plant. There are different types of water soft water, well water, chilled water, hot water etc. they are used in the different processes, for cleaning of equipment and floors. The distribution of water can be done by gravity, centrifugal pumps or by hydro flow systems. Hydro flow system is used to have uniform pressure in the water pipe lines, which facilitates operation of automatic control systems. Control of use water is required to conserve water and to reduce load on effluent treatment plant.

4 Service accommodation

Siting of auxiliary services mean proper placing of service sections providing auxiliary services such as steam, refrigeration and electricity to the dairy plant. In small and medium capacity plant, it is practicable to provide these rooms within the main building. But in large plants, it is better to group these rooms in a separate building. The arrangement of rooms where secondary equipment such as boiler, compressor, evaporators, condensers and workshop equipments are installed should be such, so as to allow easy supervision. Equipment, such as brine pumps, chilled water pumps, hot water circulating units and control should be located in a separate or beneath the floor away from processing section.

4.1 Boiler room

The boiler house, if placed in the main building, it should then be placed near the main areas utilizing steam, such as mil drying and condensing. Usually, boiler is installed on the ground floor with access from one side for the removal and replacement of the plant when required. The room for boiler accessories should be close to the boiler house. The discharge of solid fuel and removal of ash are dusty operations. Therefore, it is desirable to place the boiler section in such a way that the process room is not affected by it. This point has to be considered carefully if solid fuel is used.

4.2 Refrigeration machinery room

Refrigeration is a costly affair. Economy should be considered in minimizing the length of service lines by locating it centrally, and near the place where cooling is required. In small and medium capacity plants, the condensing unit for the cold store may be placed adjacent to it; but in large plants or where the products include ice-cream, the equipment involved will require a special room. This should be placed as close to the load areas as possible because in these and other applications of direct refrigeration, the longer the service lines, the greater the cost of refrigerant required to charge the system and greater the running cost.

Indirect refrigeration using chilled water is mainly concerned with precooling of raw milk and final cooling of pasteurized milk. In small and medium sized dairy plants, it is possible to place the compressor and chilled water tank with those for direct refrigeration. In large plant, it is better to site compressor near the section concerned. An emergency exit must be provided in the compressor room. Care for installation or replacement of equipment should be taken in view and

this would decide to site the compressor room on ground floor with easy approach to room 8in case of emergency.

4.3 Electricity

If the electricity is purchased from outside, i.e., State Electricity Board or Municipal Undertaking, then high or low voltage intake will present no unusual siting problems. In case the electricity is to be generated, the power house should then be located close to the boiler house for supervisory reasons. The switch rooms should be centrally located to economise in wiring. A large plant may have moré than one switch room.

The siting of switch room may be more difficult to decide especially in a multi-storey building. If all or most of the motor starters are housed there, power cables must be taken to the equipment concerned and control circuits must be brought in from all the operating stations. Thus, the switch rooms must be located as central as possible to economise in wiring.

4.4 Workshops and garages

Workshops include three main sections which will carry out routine repair and maintenance work of dairy in respect of Civil Engineering, Mechanical Engineering and Electrical Engineering. A small dairy will have one large workshop having three sections under one roof. For medium and large dairies, there will be separate workshops for electrical, mechanical and civil works, respectively. All workshops can be grouped and placed in a separate building near the plant.

Garages are generally of two types; one meant for parking cars tankers or other vehicles, the second one is for repairs. Parking garages are located near offices or place of work. If the plant has its own fleet of vehicles, then garages have to be erected at a suitable place on the site. The garages may be placed close to workshop with facilities for washing the vehicles and for lubrication services. Residential accommodation for key workers or essential service personnel may be constructed near the plant side but quite separate from plant building.

5 Arrangement of different sections

Arrangement of different sections of dairy means siting of various sections in relation to each other in dairy building. Arrangement of different sections in dairy must be done in such a manner that main rooms are planned and sited in relation to each other first. The product sections can then be

grouped around them. Utility sections are placed near the areas where services are needed. Garages with facilities for washing and lubrication will be placed adjacent to workshop. Offices will have separate apartments. Overall layout of the dairy plant should be of functional design and should give hygienic outlook. Arrangement of different sections in the dairy plant has effect on energy conservation and product losses. Arrangement of different sections should be based on the future expansion required in the dairy plant.

5.1 Arrangement of primary and secondary rooms

Primary rooms mean milk reception and milk treatment (milk processing) rooms. Reception and milk treatment rooms should be connected with each other. The laboratory is mainly mean for testing incoming milk and should, therefore, be located adjacent to milk reception dock. Cold store should be placed adjacent to bottle/ pouch filling room. Secondary rooms mean rooms not directly connected with milk, e.g., dry stores accessory room etc. Secondary rooms are attached to their main requirement sections. For instance, boiler accessories room will be sited adjacent to boiler room.

5.2 Arrangement concept of various sections of dairy in general

An arrangement concept of various sections of dairying in general Figure 1. It will be noticed that product sections are placed around milk storage and treatment room (main rooms). Product storage is next to product sections from where they are sent to dispatch dock. Laboratory has been placed near milk reception and refrigeration machinery room near the product storage. Utility sections near the area where services are needed. This is only a concept diagram.

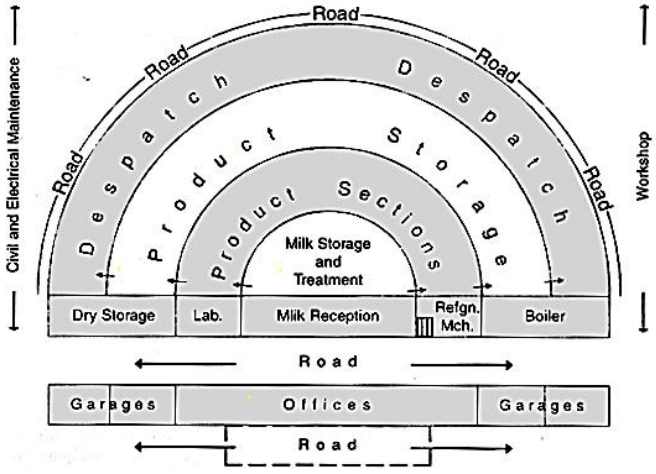


Figure 1: Arrangement concept of various sections in general

5.3 Service sections

Siting of auxiliary services mean proper placing of service sections providing auxiliary services such as steam, refrigeration and electricity to the dairy plant. In small and medium capacity plant, it is practicable to provide these rooms within the main building. But in large plants, it is better to group these rooms in a separate building. The arrangement of rooms where secondary equipment such as boiler, compressor, evaporators, condensers and workshop equipments are installed should be such, so as to allow easy supervision. Equipment, such as brine pumps, chilled water pumps, hot water circulating units and control should be located in a separate or beneath the floor away from processing section.

5.4 Office layouts and their linking with dairy plants

A dairy factory will not have only technical, dairy professionals, operators, skilled and unskilled workers, but will also have staff personnel not directly concerned with plant, but very much associated with dairy. This staff looks after all activities of dairy such as administration, milk procurement, processing, dispatch, distribution, sales and marketing of products, establishment, finance and accounts, H.R.D., security (watch and ward) and management in general.

This staff requires office accommodation comprising number of rooms properly linked. For employee comforts and convenience, staff canteen, toilets, reception lounge have also to be provided. Size of office varies with the capacity of the plant. A small dairy may have small office as number of activities will be less. Medium size dairy plant will have bigger office as compared with small dairy. In this number of activities will be more and plant may be manufacturing more products. Accordingly, staff will increase. A large dairy will still have large office with large number of staff employed. Before deciding number of rooms in office and space requirement, it is essential to know the activities, number of departments and persons who can handle the work, as number of persons employed will determine the area and room needed by them.

A small dairy may have sections or departments viz milk procurement, milk processing, milk dispatch and distribution, sales and marketing, advertising, sanitary control and hygiene, security (watch and ward), establishment, finance and accounts, dairy technology and dairy engineering.
Medium dairy will have all above departments, but there may be addition of two or more sections, such as labour welfare department (office), human resource development (H.R.D. section),

personnel department etc. Large number of employee and labour justifies the existence and importance of additional sections mentioned above.

In small dairy office, there will be one Manager who will be assisted by various Sectional Heads with suitable designations. Each Sectional Incharge will have 2 or 3 Assistants/Clerks and one Peon or Attendant. All staff will be housed in a separate building or block which will be suitably linked with dairy, except for security office which will be located near the entrance or gate of the factory. Officer Incharge of a particular section will have his room next to his working section for easy approach and supervisory reasons. For instance, Accounts Officers' room will be immediately next to Accounts Department or Section.

Medium-sized dairy plant may have one General Manager, one Deputy General Manager, one Manager, three Deputy Managers, six Assistant Managers, twelve Sectional Heads with suitable designations and three Assistants or Clerks with two Peons or Attendants in each section. Accommodation for all these staff members has to be provided and carefully planned keeping logic in mind. Sufficient space has to be provided for walk ways, passages, corridors and reception lounge with visitor's waiting room.

Large dairy plant will have big office layout with large number of employees at different levels to manage various departments. Staff pattern in large dairy organizations is somewhat different from other two small and medium size dairy plants. Here above General Manager, there is Managing Director; Board of Directors presided over by Chairman of the company. While deciding accommodation and room layout for office of this magnitude, it is essential to make provision for Chairman's office, Board Room (Conference Room), Guest Room / Guest House etc. It is a good practice to work out detail staff required at all levels in the factory including office and plant works. The organization chart may be drawn, which will give clear picture of staff position. Accordingly, office layout can be prepared. Refer Part B of the book chapter titled 'Office Layouts'.

5.5 Equipment layout

A plant will be efficient only if equipment installation is in proper order. Proper order means laying of equipment according to flow pattern of manufacturing process. The equipment must be laid as per sequence of the operations, i.e., 'what comes next'. Horse has to be put before the cart and not

a cart before the horse. For instance, milk after its reception at Milk Reception Dock, has to be weighed, dumped into dump tank, chilled through surface cooler or plat chiller before it is stored into storage tank for further processing. Here a chiller will have to be placed in between dump tank or milk receiving vat and storage tank. Milk route has to be made ass short as possible. Unnecessary travel of men and material should be avoided as it amounts to waste of time. Failure to provide adequate working space may hamper cleaning operations or may cause one operator to obstruct to another, thus causing delay. The positioning of a milk cock or other control just out of normal reach may involve as extra journey or additional effort in getting the means to perform the operation involved. Placing a conveyor or milk pipe across the route which an operator will have to take in the normal course of his duties may cause obvious difficulties and may lead to accidents which, apart from other ill effects, reduce operating efficiency. It is often seen that wrong planning and faulty installation of equipment leads to inefficiency, delays and loss of money as plant becomes uneconomical. Therefore, proper arrangement of equipment is essential for any successful plant.

5.5.1 Secondary equipment

Secondary equipment are those equipment which are not directly related to milk such as boilers, compressors, condensers and workshop equipment. These equipment should be in a separate room from the main part of the dairy plant. Equipment, such as brine pumps, chilled water pumps and hot-water circulating units and controls should be located in a separate room or beneath the floor away from processing section.

5.5.2 Bulk milk receiving

A minimum clearance of 5 ft (152 cm) above the highest milk tanker should be allowed for cleaning spray head and balancer. An 8 ft (244 cm) working space should be provided behind each tanker for ease in handling the hose and making connections. The floor at rear of the truck should slope ¾” per ft (1.9cm/30cm) for fast drainage.

6 Arrangement of processing equipment

The main idea for proper arranging the equipment is to achieve maximum efficiency and economy in respect of installation of the equipment and to provide facilities to staff looking after the equipment for smooth running of the plant. For planning a layout of the equipment, use of layout

planning table and model planning is highly recommended. Consideration must be given to the cleaning-in-place system (C.I.P.) when placing the equipment. Storage tanks should be in a battery such as in a row, so that, a common supply and cleaning solution return line can be in a buttery such as in a row, so that, a common supply and cleaning solution return line can be used for all tanks. The same idea holds true for the arrangement of pasteurizing vats or similar pieces of equipment. Regular order of the equipment installation is essential and must be in accordance with flow pattern of the product.

A pasteurizer would probably comprise the heat exchanger, hot water set, milk pump, float tank and possibly an instrument panel together with the inter connecting milk piping. A bottling line would consist of a bottle washer, filler, capper, and associated conveyors. These equipment should be installed in regular order without any obstruction in the way.

6.1 Milk piping

The layout of interconnecting milk piping system should be decided keeping in view the method of cleaning. There are two methods which are commonly adopted for cleaning milk piping. These are: (1) manual cleaning method and (2) cleaning-in-place (C.I.P.) method.

If manual cleaning method is adopted, it must be clear that the pipes have to be dismantled frequently for cleaning operations and for this purpose, it is essential that approach to pipe lines is made very easy, i.e., piping system is easily accessible. For this piping supports from ground (floor) is preferred for supporting overhead pipe lines which are 7 to 8 ft above the ground level. Piping supports should be placed at a distance of about 3 meters or about 10 ft. All pipes carrying milk are of stainless steel as they are easy to clean. Sanitary piping is recommended for dairy industry.

For cleaning-in-place method, approach to pipe line is less important as piping will be dismantled relatively infrequently. Layout of piping in C.I.P. system has to be planned carefully because the purpose is not only conveying or carrying mi8lk but also cleaning. Contamination has to be avoided in all cases. In large installations, it will be necessary to arrange for part of the pipe system to be cleaned while another part is conveying milk, and precautions and safeguards must be incorporated to prevent accidental contamination of milk by cleaning solutions or detergents. A

milk piping must be so arranged to minimize loss of product at the end of process run to ensure that all cleaning solutions are removed from plant before use. For C.I.P. cleaning of pipe lines, milk piping may be supported from ceiling. In this metal suspension rods are fixed to ceiling. This gives a clear floor area with no obstruction and operations are carried out smoothly.

6.2 Can washing

Conditions and environments under which milk and milk products are processed are of great importance to customers. Pollution free environment and cleanliness become the prime factor for dairy industry. Cans in which milk is brought are often washed and cleaned well at dairy. Installation position and arrangement of can washing machine in relation to other respective equipment must be done in such a way so as to avoid contamination. The can washer must be installed in milk receiving room or at Milk Reception Dock covered from sides. It has to be placed adjacent to weigh tank (milk dump tank) in between dump tank and can washer, there will be drip saver so that any droplet left again goes back to weight tank. Milk may be transported up to tipping point on can trolleys or by means of conveyors. A stand by washing trough with cold and hot water facilities can be helpful in case of emergency. It will be clearly noticed that 'can cycle' ends at milk reception / milk receiving room only as after cans are washed, these are loaded on the same vehicle in most of cases and returned back to milk producers for next day bringing milk. Some space equal to one-hour load capacity has to be kept on floor for washed empty cans as precautionary measure. Ultimately these have to be picked up within an hour's time. A minimum of 3 ft. distance is desirable between dump tank and can washer may be rotary or straightway can washer.

6.3 Pasteurizer, homogenizer and ice-cream freezer

As mentioned earlier under arrangement of processing equipment, pasteurizer and other relative equipment along with it have to be installed in order. But there are some other accessory equipment which are integrated into HTST and UHT pasteurizers. These are clarifiers, separators and homogenizers. Clarifiers and separators when installed so as to operate on the heated product must be connected in such a way that they will not reduce the holding time below the legal minimum. As all fluid milk and all ice-cream mix are homogenized, homogenizers are integrated into continuous pasteurizing systems. Homogenizing temperature must be at least 120 ^{o}F. The homogenizer must be located either between the regenerator and heater section or after the heater.

Homogenizers work better when the product is delivered to the suction manifold under positive pressure than when they must draw the product into the suction manifold. The timing pump and downstream resistances supply the necessary pressure in most installations, but when there is a lack of pressure on the suction manifold, a centrifugal pump immediately upstream is recommended. It should be electrically connected, so that it can run only when homogenizer motor is running.

Ice-cream freezers and hardening room: Hardening cabinets (for small units) must be placed close to homogenizer. If a plant is incorporating a separate section for ice-cream making, then all relative equipment for ice-cream manufacture have to be installed in regular order sequence-wise.

6.4 Consideration of cleaning-in-place system

Cleaning in place C.I.P. means in place cleaning of equipment, i.e., cleaning solutions are brought to equipment and cleaned there only instead of equipment being dismantled and taken to separate place for cleaning. For proper performance of any C.I.P. system, all pipe lines must be properly fitted, properly pitched and rigidly supported. Special attention must be given to the supporting arrangement since proper support alone can assure maintenance of proper fit and pitch. Gaskets and joints which are protected from stress will be long lived 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. Ingenuity is essential in solving mounting problems at hand when installing C.I.P. system.

General recommendations regarding installation of C/A systems and C/A cleaned equipment are given below:

(i) Tank trucks which are to be spray cleaned should be pitched at ¼ inch per foot from front to rear to provide for efficient high-speed unloading and cleaning operations.

(ii) Storage tanks that are to be spray cleaned should be pitched at ¼ inch per ft from rear to front to provide rapid drainage and continued positive recirculation of cleaning solution.

(iii) Where tanks are associated fill-discharge header systems are to be mechanically cleaned, these tanks should be installed with the outlets 18 to 24 inches (45cm to 60 cm) above the floor, or higher, if necessary, to accommodate the required number of lines. This height

provides good return solution flow from tank washing operations and places all valves at a height convenient to the operator for product-flow control and cleaning.

(iv) All product lines should pitch continuously to pumps being supplied by these lines.

(v) All product transfer lines should pitch from a point above the transfer pump involved continuously if possible, toward the constant level tank, storage tank, or filler bowl being supplied.

(vi) All C.I.P. cleaned product lines should pitch continuously towards one or more drain ports.

(vii) Tank cleaning return lines should pitch continuously from the tanker outlet valve to the cleaning return pump involved.

(viii) All connections should fit precisely, so that nipples and elbows can be easily installed and removed for making product piping and C.I.P. connections.

7 Dairy plant layout

The main objective of dairy plant layout is to design the dairy plant to carry out all dairy processing operations. The knowledge of estimating the requirement of various equipments, location of equipments in different sections, space requirement for equipment and the general civil aspects of building construction. The engineer should have very clear and complete understanding of requirement and management policies. The management policies decide the future expansion requirement of a dairy plant. Management decision with respect to the addition of new of products is important to be considered at the stage of dairy plant layout. It also includes process schedule to be followed and requirement of different utilities.

A well-designed layout must facilitate production operations, minimize material handling maintain flexibility of the operation for alteration and expansion, minimize investment in equipment, make economical use of floor area, promote effective utilization of the labour and provide for employee convenience and comfort.

It is up-most important to design optimum size of dairy building. Some enterpriser engages an architect to prepare the plant layout for an attractive design and consult dairy equipment manufacturers for ideas regarding latest machinery. However, involvement of dairy engineer in the layout is very vital to take care of all necessary requirements. It is advisable to make judicial use of land available and optimum cost in construction of building.

Process schedule is one of the important activities of planning, before diverting milk to different section for product manufacturing. It is prepared well in advance to give instructions to boiler operator, refrigeration plant operator, and different process section in-charge to plan for the activity of different unit operations for processing the milk to have smooth operation of the process. It also helps to prevent product losses and to have efficient use of equipment, energy and water.

7.1 Principles of dairy layout

As far as possible dairy layout engineers should try to incorporate the following principles in layout, which, in turn, will help in having an economical and efficient dairy plant. It is often seen that the dairy designer or layout engineer is not in a happy position because he is always confronted with one or the other layout planning problem, which makes him unable to apply all the principles described hereunder:

(i) The milk route should be as short as possible. This will minimize the cost of pipe length and save time in cleaning.

(ii) Reception and dispatch platforms must be arranged in relation to plant in such a way that congestion of transport vehicles is avoided.

(iii) Small dairy handling milk up to 20,000 litres/day may have reception and dispatch at one dock as there will not be much rush of vehicles. In large dairies, this separation is essential. Generally milk reception and dispatch of washed cans is one side (because washed cans are reloaded on the same vehicle and returned to milk producers) and dirty bottle reception is on the other side.

(iv) Where space is available, single storey building is most suited. The plan may have a rectangular shape with roads on all sides.

(v) The floor level of milk reception and dispatch docks and of all rooms concerned with milk cans and bottles should be at the same height above the ground level suited to vehicles. However, the weigh tank and raw milk pump should be at a lower level in order to have a convenient tipping height. A well or pit must be constructed for the weigh tank and raw milk pump.

(vi) The raw milk storage tank and pasteurized milk balance tank may be mounted on a staging in order to save floor space and to provide a gravity head to fillers.

(vii) If it is desired to have a refrigeration compressor room and boiler house in the same building, the floor level of these rooms should be at part with ground level. This gives extra height to boiler and affords a study foundation to compressor.

(viii) Laboratory should have easy approach to processing room, reception room & filling room.

(ix) Separate apartments should be assigned for offices.

(x) Boiler should be located near the place where steam is required.

(xi) Refrigeration machinery room should be near the process room and cold store.

(xii) Security and watch and ward offices should be located near gate.

7.2 Different types of layouts

Planning is the way of proceeding or scheme of arrangement for executing any work or project. Planning a layout for a dairy calls for careful thinking. Designing a dairy plant layout is a joint venture of Architects, Dairy Managers, Dairy Engineers and Administrators, because it is an overall managerial function. The ideas of several technocrats are sought and future requirements are estimated as accurately as possible. The anticipated capacity in 10 years, products to be manufactured, types of packages, methods of distribution, material handling, loading out facilities and office space are the examples of items to be kept in view while planning layout. The plant layout engineering function is to achieve an efficient plant layout through the utilization of logical, well through procedure.

Top management policies affect the plant layout as policies determine the plant layout objectives and scope of plant activities. The layout engineer must have a clean and complete understanding of those top management policies, that have a bearing on plant layout objectives. A knowledge of managerial policy with respect to the future volume of production and the size of business firm is of particular importance to dairy plant layout engineer, because it will point to the need for providing for future expansion or contraction in the layout. Included in expansion programmes are management decision with respect to the addition of new or related lines of products. A plant layout should be so planned and arranged, that the needed capacity to produce new or related products can be added at low cost, with minimum of plant revision and interruption of production schedules.

A good layout must improve or facilitate production operations, minimize material handling maintain flexibility of the operation for alteration and expansion, minimize investment in equipment, make economical use of floor area, promote effective utilization of the labour force and provide for employee convenience and comfort. Many companies engage an architect to draw up a plant of an attractive design and consult dairy equipment manufacturers for ideas regarding latest machinery. The common mistake lies in making too large or too small a plant. The size of dairy plant is a matter of consideration and prudence. It has often been found unwise and erroneous to construct a very large building in as much as it may not be paying especially in new business. Many concerns have faced bankruptcy due to overhead cost on massive construction. Operational layouts describe operations which take place in processing or manufacture of any item. All operations involved are represented diagrammatically in chronological way, i.e., sequence-wise-what comes next on the paper like any flow diagram which can be easily understood by a layman. There is no restriction in showing pictorial views or three-dimensional layouts. For instance, an operational layout of a butter making factory will differ from that of ice cream making plant as two have different operations to achieve end product. These layouts are usually drawn to impress upon management board which may comprise of professional and non-professional members for quick understanding of the proposed project. Typical layouts are prepared for different types of product manufacturing in the dairy plant. The layout should be functional to facilitate each unit operation involved in product manufacturing. Figure 2 shows typical layout of different product manufacturing sections and integrated product plant.

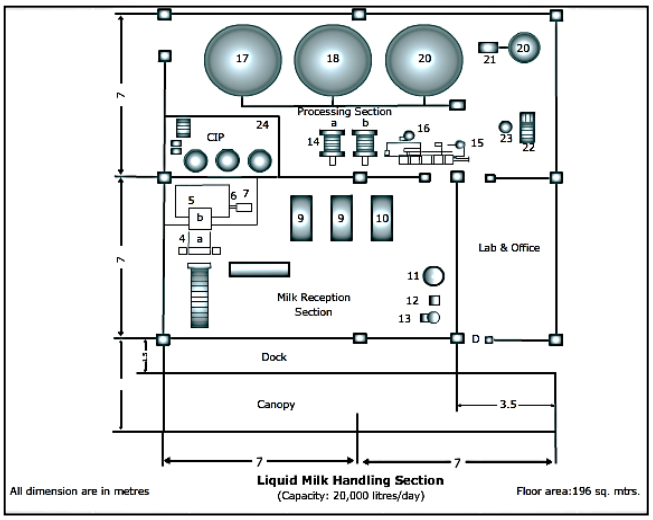


Figure 2.1: Liquid milk handling section

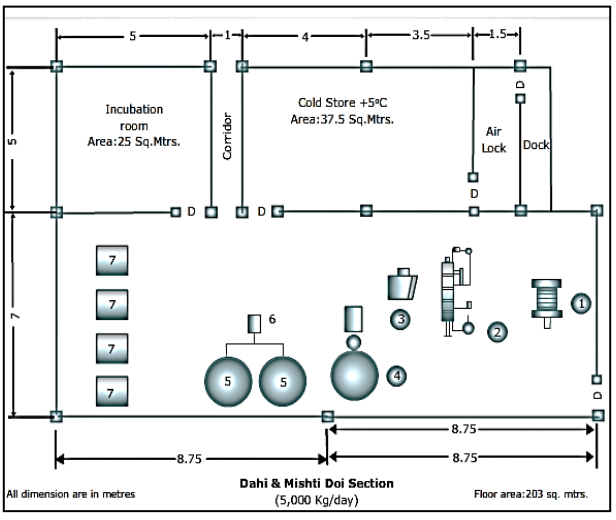


Figure 2.2: Dahi and Mishti dahi section

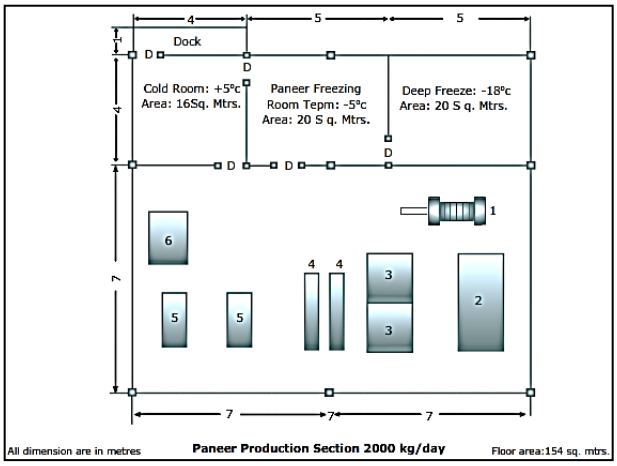


Figure 2.3: Paneer production section

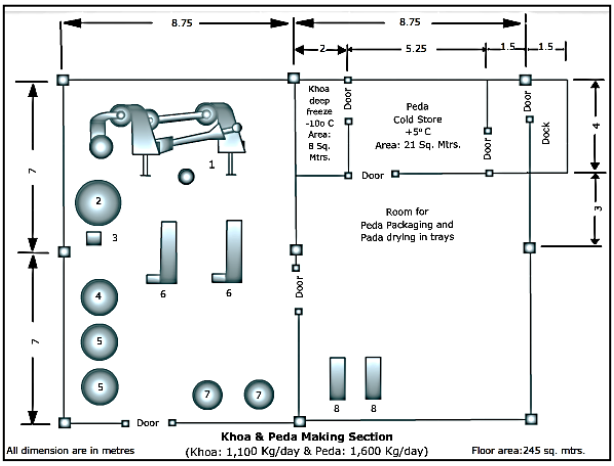


Figure 2.4: Khoa and Peda production section

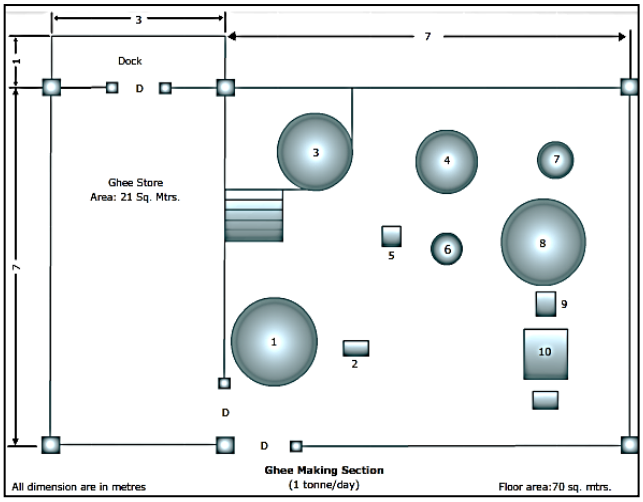


Figure 2.5: Ghee making section

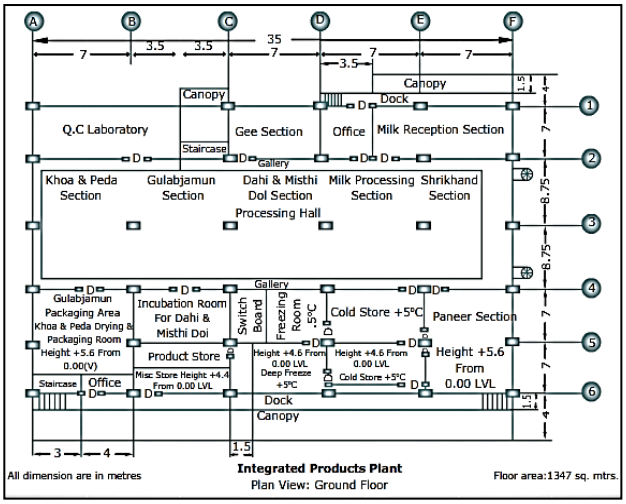


Figure 2.6: Integrated Product Plant

8 Bibliography

Chander, L. 2004. Dairy Plant Layout and Design. Directorate of Information and Publ. of Agriculture ICAR.

Farrall, A. W. 1963. Engineering for Dairy and Food Products. John Wiley and Sons, New York.

Hall, H. S. and Blombergsson, H. 1963. Milk Plant Layout. Food and Agriculture Organization Publ. United Nations.

Moore, J. M. 1962. Plant Layout & Design. Macmillan Publ., USA.

Patel, S. M., and Bhadania, A. G. (n.d.). Dairy Plant Design and Layout [e-course]. e-Krishi Shiksha. http://ecoursesonline.iasri.res.in/course/view.php?id=75

*****

Maintenance of Dairy Processing Equipment

Ankit Deep

Scientist, Dairy Engineering Division, ICAR-National Dairy Research Institute, Karnal

1 Introduction

Although the length of service one can expect from any given machinery or equipment will depend on the durability associated with its design and workmanship, the way it is used and handled will influence greatly whether or not its utility will extend as long as it was designed to last. The expected useful life of most dairy equipment is about 8 years, implying a depreciation of 12.5% per annum. With good care and optimum maintenance, the useful life of such equipment can easily be extended by 30-35% or more.

As we know the milk processing equipment are expensive, hence, need greater care to give best results. One way to maintain the equipment is to run as long as it works and repair it when it stops working. It is called “Breakdown Maintenance”. A scientific way of maintenance would be to do “Preventive Maintenance” (PM). As a thumb rule 6-12% of machine cost will be required for proper maintenance of machine every year.

In order to carry out PM programme, planning is done. We will learn different records and forms used to follow up schedules. These will act as guidelines for plant operators. These records also indicate the preparations for future planning. What are the needs of spares, oils and greases, etc., can be easily decided. Oiling and greasing are lifeline for individual machine. Every equipment has been recommended a lubrication schedule. For every dairy plant, daily, weekly, monthly and quarterly planning can be done. A lubrication route for the technician can be suggested and appropriate checks planned.

Dairy equipment is required to work under unfavourable conditions of high moisture, chemical environment, and temperature and pressure stresses. These conditions do affect the life of material with which the equipment is fabricated. Also, the aesthetic look of equipment is need of such industry. It gives psychological impression to workers and the public for the conditions prevailing within the plant. All the processing equipment need water, steam, refrigeration, air and electricity. These are supplied through appropriate pipelines and cables. Well-maintained service lines not

only reduce the losses but also offer good look. Injuries and accidents can also be prevented with little care.

Most of equipment are provided with components made of rubbers. These are unavoidable, yet designed with utmost care. To maintain quality of product the upkeep of these components are a must. Readers will learn, as to how to take care of these parts and prolong their life.

Finally, even if each and every equipment is in order, the plant surrounding, landscape sanitation needs utmost care. Building maintenance is the first impression given to the visitors and public who pass by this unit. All walls, seepage, odour, well-trimmed grass and shrubs, well parked vehicles, etc. offer reputation of the dairy plant, as a first impression.

2 Dairy Equipment Maintenance

2.1 What is Maintenance?

Maintenance is the upkeep of plant and machinery in proper working condition at all times

2.2 Types of equipment maintenance systems

2.2.1 Preventive maintenance

2.2.1.1 Principles of Preventive Maintenance

Dairy equipment are expensive due to their specialized construction. Some of these are sophisticated and imported, hence, needs proper attention. In general, there is less appreciation to the maintenance activity, Preventive Maintenance (PM). Its importance is realized at the time of break down. A PM programme is a “procedure” designed to increase plant productivity, decrease maintenance, reduce operating cost, and to increase life of the equipment. It involves:

i. Routine external inspection: It means external viewing in terms of noise, vibration, heating or any sign of malfunctioning. This is noted and corrected, if any.
ii. Periodic internal check-up: It is done when the equipment is shut down at the end of operation. This is not a major repair action. One has to decide the duration after which this check-up is done. In this adjustment of control instruments, replacement of lubricants, surface touch ups, etc. are carried out. During this check-up, looking at the condition of equipment can make an idea on the possible major over-haul.

iii. Major repair/over-haul: Major repair is then planned preferably in the season when the equipment is not in use. Most of the major repairs are carried out during summer month when the milk handling capacity is less. For refrigeration section, the repairs are planned in winter months. Prior to shut down selection, procurement and stocking of spares must be ensured.

iv. Evaluation of equipment performance: A good engineering function is to carry out routine evaluation of each and every equipment. Due to normal operation, the efficiency of equipment reduces; this in turn affects the productivity. There are set procedures to calibrate and measure the flow capacities, heat transfer efficiency, product output, utilities consumption, etc. Again, the frequency of such evaluation is a matter of experience and planning. The awareness on the part of management is also an important factor.

v. Record keeping is a part of PM procedure: We must maintain the work and breakdown record of the individual equipment. This will also indicate the repairs carried out. These records help in subsequent planning. These records are called "Log books". Proper proforma is developed to indicate exact duration of running, various inputs utilized, efficiency and check parameters, records of repair and nature of complaint and the person who carried out the operation and repair. Periodic verification is carried out by superiors as a check and feedback. If above procedures are adopted, the cost of maintenance will be less, equipment efficiency will improve, plant productivity will increase, accident possibilities are avoided, and finally the life of expensive equipment is extended.

2.2.1.2 Development of Plant Maintenance programme

Very first step for development a PM programme is to record basic equipment data with appropriate classification. Recording should be simple but reliable. Usually, card file system known to engineers could be adopted. This information can be required any time, hence, be readily available and preserved.

i. Administrative information: This should include equipment's name, its supplier, sanction order, date of purchase, date of commissioning, its cost, etc. This will be needed at later date.

ii. Technical details: Information such as serial No./model/style, capacity/speed/rating or size, recommendations of manufacturers for installation/operation/lubrication type and quantity/frequency of lubrication replacement and precautions, if any.

iii. Specific details: Mechanical, electrical and utilities required such as regular water, soft water, refrigerant, steam, fuel, electricity, compressed air, and quantity of effluent discharge, etc. It may also record the working pressure and temperatures, voltage, insulation and the inventory number given while entering in record to identify it.

iv. Identification of critical points: Now decide the list of specific points of each equipment to be inspected, and point/ area, which should not be inspected. Obviously, the point, which wears out fast or gets eroded/damages, needs regular inspection. The parts dangerous to the worker or likely to stop the plant operation should be avoided. Natural question comes in mind is as to what to inspect. The answer will be from the recommendations of equipment manufacturers manual. Then prepare a checklist in the order of priority. The idea is to give a written guideline to the person who will carry out inspection. This checklist helps to recall and assure proper execution instead of leaving on the memory of the individual.

v. Frequency of check-up/inspection: It is decided based on the condition of equipment. Older equipment needs frequent inspection as compared to newer ones. Similarly, there may be safety recommendations; hence, frequency of inspection will be increased. The extent of equipment used and the type of wear will also play role in deciding the frequency.

vi. Equipment performance: Finally, we should keep on evaluating the performance of equipment. Normally equipment performance will decrease with time. It will then increase cost of production. The report/remark of operator in the logbook will act as a feedback. Hence these comments be seen and compared with the manufacturer's recommendations. If it is felt that the performance in term of flow, capacity, quality, utility consumption etc. are above normal then actions are required. Planning is then made as to when to shut down the equipment, what spare parts are needed and made available. It is also assessed as to whether skill is available within the maintenance group or help from outside will be needed. How much financial burden will be on the dairy and if the money is available. These are some of the crucial pints of judgment of efficient PM programme.

This is the persistent and systematic procedure for the care of all production, control and auxiliary machinery in a dairy factory including regular servicing, upkeep and overhaul, record keeping and stocking of essential spare parts for the purpose of preventing breakdowns and emergency shut downs for repair.

Preventive maintenance must begin with the purchase of the right type of equipment for any specific job. The machine must always do the job of its right capacity for high durability. If a machine that is of low capacity is consistently being called upon to do a job meant for a high capacity one, no amount of preventive maintenance will cure it!

Preventive maintenance is useful and necessary because it will prevent loss of money and profits due to (i) Unnecessary machinery shut downs; (ii) Shortened machine life; (iii) Machine inefficiency and (iv) Reduced productivity.

The main objective of preventive maintenance is to:

- Increase the efficiency and improve the performance of all processing and service equipment
- Increase the overall productivity of the entire plant by achieving coordinated and continuous operation of all plant equipment
- Increase the certainty of meeting daily production schedules
- Reduce unscheduled down time
- Extend the useful life of all plant equipment
- Minimize property and personnel hazards.

2.2.1.3 Elements of preventive maintenance programme

A good preventive maintenance programme must include the following elements:

- Routine external inspection of all equipment
- Periodic internal inspection
- Systematic lubrication
- Prompt adjustment, repair or replacement of defective part(s)
- Record keeping system
- Periodic analysis of system(s) operating parameters
- Spare parts inventory and inventory control
- Scheduled major overhaul of machinery
- Economic basis for scrapping off of equipment
- Maintenance cast analysis and reporting to management
- Capable maintenance supervision

All the above elements are essential for an effective PM programme. None should be overlooked or ignored.

2.2.2 Scheduled repairs

Replacement of parts at preset time or service intervals may be prescribed for certain parts. They must be replaced when due for replacement. It may apply for gaskets, O-rings; oil and air filters.

2.2.4 Economical Maintenance

The secret of economical upkeep is to train operators to handle the equipment as if it were their own, and to keep a continuous inspection for the small things that go wrong. This should be supplemented by a periodic general inspection. In small plants, it is advisable for each operator to take care of the equipment he/she runs, when minor repairs are needed since there is seldom an engineer around. In large plants, a trained engineer should usually be available for all required repairs.

2.3 Importance of following manufacturer's instruction

The things which go wrong with equipment can often be easily solved by reference to the manufacturer's instruction manual. It is very unfortunate if equipment is unsatisfactory when a simple adjustment as explained in the instruction manual would solve the problem. Most manufacturers of dairy equipment furnish complete instructions that show exactly how the equipment is to be operated, especially on major items of the equipment e.g. pasteurizer, refrigeration machine, Ice Cream Freezer, homogenizer etc.

Most breakages of machinery and loss of efficiency, together with unsatisfactory operation can be traced from failure to follow the manufacturer's instructions. It is impossible for busy superintendent to carry around all detailed instructions for all his machineries. It is therefore important at all times that the instructions be available to the man who operates the machine. The superintendent/supervisor should occasionally check them over with the operator to make certain that the operator has absorbed the information in the instruction book. Operators should be responsible for their machines.

2.4 Common maintenance problems

The commonest maintenance problems include:

- Lack of proper lubrication
- Breakage due to operators not handling the machine properly and according to instructions or using wrong tools to open or service a machine
- Leaks due to rough handling of equipment or improper assembling or mounting
- Corrosion due to improper washing and cleaning methods (use of wrong detergents or too high concentrations and/or temperatures).

Care directed to the above items will pay dividends in the long run.

2.5 Common Maintenance Procedures

2.5.1 Lubrication

2.5.1.1 Guidelines for effective lubrication programme

A guideline for proper lubrication of the equipment for any dairy plant can be prepared from the recommendations made in manuals of individual equipment. Manufacture of equipment does indicate the type, quantity and lubricant required. From various lubricants recommended, a common list of lubricants could be prepared to minimize diversified needs. Mark the points of lubrication on equipment and in the record book. Then, plan a schedule and route for technician. Evaluate the suitability of lubricant application method and change if required. Normally the cost of lubricants ranges from three to ten per cent of the machine cost.

With the information gathered, a “Route Map” could be prepared. This map covers all machines that can be lubricated in one shift or a day. This way daily, weekly, monthly, quarterly, semi-annual and annual lubrication chart are prepared. A Supervisor or Engineer needs to monitor these charts for effective lubrication programme.

Lack of lubrication is one of the principal causes of equipment breakdown. The best solution is to have a regular lubrication schedule, and perhaps a lubrication chart for each machine, setting the frequency of lubrication, type of lubrication needed, and places to be lubricated.

Modern equipment calls for certain types of lubricants for certain types of bearings e.g. light, high speed bearing will require a light oil, whereas a heavy duty, low speed bearing will require heavier oil.

Bearings that are operated at high temperatures must have a lubricant specially adapted for this use, just as those bearings that operate at extremely low temperatures will require zero oil.

Many dairy plants have rather high humidity and for that reason the moisture problem should be considered. Certain lubricants are available that resist rusting and corrosion due to moisture. There are also oils that resist emulsification with water and are advantageous for flooded systems of lubrication where gears and chains run in oil.

The most tightly enclosed oiling system will with time allow moisture to accumulate. It is essential to occasionally check the oil in an enclosed drive to make certain it is not contaminated with water. Usually, the water will collect at the bottom and may be drawn off easily.

2.5.1.2 Lubrication of Equipment.

How to lubricate motors will depend on what type of bearings is used. Sleeve type bearing are usually lubricated with oil fed by a ring oiler, or if a it is small motors by felt wick. The type of oil used for these bearings are oil with viscosity of 300-500 seconds at 100° F. For anti-friction bearings a multipurpose grease of medium consistency is recommendable.

Speed Reducers. Reducing gears and their bearings are almost invariably enclosed in oil tight housing, which has filling level testing and drain plugs. Well-refined oils containing an oxidation inhibitor provide the best results. Depending upon gear types and other design and operating factors, the oil used can have a viscosity of 300-2000 seconds at 100°F; it should as well be rust-inhibited and foam inhibited.

Conveyors. All bearings should, if the design permits, be lubricated with a water repellent grease, as forcing grease into bearings forces dirt out and provides a seal against the entrance of all kind of foreign materials. If the bearings have to be lubricated by oil, oil of a rust-inhibiting type with a viscosity of 300 seconds at 100°F should be used. The chains are often lubricated by soap-water solution.

Air compressors and vacuum pumps. The viscosity of the oil used for both vacuum pumps and air compressors affect the operating efficiency very much. If oil with too low viscosity is used it will pass the rings, and the result will be increased oil consumption and inefficient pump operation. It

should be kept in mind that compressor oils should march the pressure and temperature conditions. The type of oil used should be rust and oxidation inhibited, non-foaming and have a viscosity of 300 seconds at 100° F.

2.5.1.3 Handling of Lubricants

In many cases, bearing failures may be traced directly to improper lubrication responsibility and to the handling of lubricants. Some of the factors concerned are:

- *Centralised Lubrication Responsibility*. Lubrication responsibility should be given to a trained specialist who is fully familiar with the most exact lubricating requirements of the equipment.
- *Planned Lubrication Schedules*. Schedules outlining the type of lubricant to be used and lubrication frequency should be established and followed to the letter.
- *Lubricant identification*. Frequently the product loses its identity after being received by the used and becomes just another barrel of grease. Good housekeeping will assure clean and well-marked containers.
- *Lubricating Devices*. Adequate lubricating devices should be supplied for proper lubrication. Proper lubricating devices make it easier for personnel to maintain an adequate lubricating schedule. The use of Teflon for bearing has increased greatly. It is a self-lubricating plastic material.
- *Accessibility of Lubricating Devices*. Lubrication devices should be placed in accessible locations to ensure safety of the operators and to encourage attention to lubrication.

2.5.1.4 Indications of Faulty Operations of Anti-friction Bearings

Faulty anti-friction bearing operation can sometimes be distinguished by abnormal noises. Accurate diagnosis, however, is possible only if the bearing is dismantled and inspected. Some of the defects that cause noisy bearing operations are:

- A scraping noise indicates the presence of foreign bodies e.g., metal chips, dirt of sand.
- A regular grinding noise indicated cracked or jammed belts or rollers; and irregular grinding noise may indicate that the bearing cage is rubbing against the inner or outer race.
- A clear, metallic ringing, almost a whistle, indicates lack of lubricant.

- A jotting noisy indicates surface crumbling or races and rolling elements out of line. Another cause is hardened deposits on the roiling elements resulting from lubricants of poor quality or improper type.
- Alternatively, strong and weak rattling indicates a loose ball or roller or too much play in the bearing cage.
- A regular humming sound indicates that the bearing is in normal operation.

2.5.1.5 Over or under-lubrication.

- Over lubrication causes overheating and waste of lubricant.
- Under lubrication results in excessive wear, overheating due to friction and as a result reduced bearing life.
- If a high speed, antifriction bearing equipped with a grease fitting is pumped full of grease, the grease increases in volume, and excessive pressures and temperatures result because of the churning of the lubricant and the resulting rise in temperature.
- It is recommended that a bearing be padded or filled not more than 1/3 or 1/2 full. This will allow the grease, under operating conditions, to expand without building up excessive internal pressure.

2.5.1.6 Contamination and Corrosion

The presence of abrasive contaminants such as dirt, dust, metal particles, hardened grease deposits and other foreign materials is probably the principal source of antifriction bearing damage and failure. The other important cause for bearing trouble is corrosion resulting from moisture introduced by handling or by exposure to excessively wet conditions and inadequate sealing. Grease containers should be kept covered, grease dispensing equipment should be cleaned, grease fittings should be wiped clean before refilling.

2.6 Corrosion of Dairy Equipment

Corrosion of dairy equipment is one of the major dairy equipment problems, as it accounts for great annual loss to the industry. Corrosion is caused by an electrochemical action which takes place in the presence of moisture and causes the surface to pit or rust. The best protection for the exterior surfaces of the dairy equipment is to keep them well painted with a good quality moisture proof and heat resistant paint. Some parts, however, can better be protected by some of the metallic

coatings e.g. galvanising, tinning or chrome plating. Corrosion and pitting of the interior surfaces of vats and machinery are best prevented by attention to proper cleaning methods and by keeping the equipment as dry as possible when not being used. Aluminium plate is hung in the vat to prevent electrolytic corrosion of tinned copper vats in some plants.

Proper ventilation of the dairy plants will reduce casting and maintenance since moisture will not collect on the surface of the equipment and remain there for long. Ammonia is corrosive hence all ammonia leaks should be prevented.

2.6.1 Care and cleaning of SS surface

Stainless steel (SS) is expensive metal and therefore, needs care. The frequency and the extent of cleaning depend on the extent of usage and the condition.

i. Cleaning of soft deposits: Ordinary deposits like dirt, grease are cleaned with mild detergent (soap) and washed and dried.
ii. Hard deposit: However, hard deposits need different treatments such as rubbing/buffing with polishing powder and SS brushes. Soft cloth or pads are used to shine the surface. Plastic sponge or fibrous brushes are also safe to use. Avoid iron wire brush (steel brush) and should never be used for rubbing. This brush will leave iron particles on SS surface, which will cause rust.
iii. Care with sanitizers: If Chlorides/Bromides/Iodides based chemicals used under acidic condition for long; there are greater chances of corrosion, hence should be washed properly.
iv. Care with salt solutions: These leave dirty spots on drying, hence should be washed after use. No paint or any coating is done on SS surface. Sometimes rust like appearance may occur which is due to some iron chip or part adhered on SS surface for cleaning. 5 to 15% caustic soda (hot or cold) is commonly used. Sometime 0.1 to 2.0% hot solutions of Sodium Metasilicate, tri-Sodium Hexa Metaphosphate, and Tetrasodium pyrophosphate, Sodium Tripolyphosphate are used as excellent removers. Organic solvents are sometimes used to remove oil, grease, paints or hard deposits. These organic solvents are ether, alcohol, kerosene, gasoline, etc. Highly adherent ink, paint, etc. can be removed by butyl acetate. For very heavy water deposits, 15-20% nitric acid can be used with caution. Acid cleaning is followed by proper washing to remove any trace of acid.

2.6.2 Care of Tinned surfaces

To get best service from a tinned surface, two principal considerations are important. First, tin is soft metal and is easily scratched and eroded by abrasion, hence abrasives such as steel wool and washing powders etc should not be applied on tinned surfaces. Secondly, tin is acted upon by electrolytes, when in contact with other metals and under certain conditions extensive impairment of the tin surface results. The tin may disappear completely or localised spotting and removal may occur.

2.6.2.1 Re-tinning of surfaces

Tinned surfaces require occasionally re-tinning. This should be done by RETINNING experts with necessary equipment.

2.7 Maintenance of rubber and gaskets

Dairy equipment have number of joints and connections requiring leak proof arrangement. Stationary equipment like plate type heat exchanger (chiller or pasteurizer) will have gaskets between individual plates. Moving or revolving equipment such as pump shaft or cream separator will require shaft seals, 'O' rings etc.

i. Characteristics of rubber and gaskets: All of these must be chemical resistant, as acid and alkali are used as detergents. These should be resilient to offer leak proof joints. These are of varied shapes and sizes to suit particular location or purpose for which these are used. They are required to work under high temperature and preserves, yet should not got damaged or contaminate the milk and milk products. It is, therefore, important that the rubber and gaskets should be of non-toxic material, should be heat resistant, durable and should not get damaged with the chemicals used for cleaning.

ii. Care with gaskets and seals: These have comparatively shorter life, hence require utmost care. Since these are between joints or moving parts, over tightening be avoided. You will notice leakage from pasteurizer at the start. Slowly the leakage will reduce and may stop without tightening the plates. This is due to heat expansion taking place. If you notice leakage even after enough warming up, then plates may be tightened. Over tightening may permanently deform the gaskets. This will result in reduced thickness/gap between the plates. Ultimately, this will affect the capacity of pasteurizer. Similarly packing/'O' ring in the union or joint

should not be over tightened. Usually, a good joint should be leak proof. This could be made leak proof by hand tightening and does not require a spanner. Gaskets between pipe joints get damaged while reassembling. This is due to poor alignment of pipelines. As discussed in the previous chapter, the alignment must be corrected before tightening the joint.

iii. Pump seals: These also need good care. Seals are expensive and require correct assembling. The carbon seal face rubs the stationary wall of the pump body, hence, the surface should be well polished and clean. While fixing the new gasket, old gasket and its particles should be removed with either a gasket remover or cleaned with the help of a sand paper.

2.8 Tools

The key to caring for tools is to have a rack for each tool stacked and painted in distinct colour. If a tool is to be frequently used on a special machine, the tool rack should be near that machine. The general-purpose tools should be kept in a locked cabinet with the outline painted on the back of the wall cabinet for each tool. Small tools can be kept in a portable metal box.

2.9 Care of pipes and fittings

You will find that a milk processing plant is full of various types of pipes. Various utilities like milk, water, air, steam, chilled water, hot water, refrigerant, electricity, etc. are transported/conveyed through these pipes. To regulate and control flow, different valves and fittings are provided within this piping network. This network must work without the loss of product, energy, corrosion, noise/vibration, leakage, etc. They should also offer ease in working and accident-free operation.

i. Care of pipelines: Pipeline once laid, very little can be done. Only protection from moisture, oxygen and acidic environment should be done. If pipe is imbedded in soil, asphalt covering will protect it. Overhead pipes are kept dry and painted. Inside pipe corrosion can only be minimized if entry of oxygen could be reduced. Even dissolved oxygen in water affects it.

ii. Care during installation of pipes: Water hammering is due to movement of water with jerk. This is caused by sudden closure of opening of fluid and accumulation of residual fluid inside pipe. This obstructs the normal flow. Hence, pipelines are given proper slope and drainage point to avoid any accumulation. Pipe supports are adjusted to give proper slope to the pipes.

iii. Maintenance of pipes joints: Some pipes carry hot and cold fluid like steam and chilled water. The temperature change causes thermal expansion of metallic pipes. These pipes have provision to absorb expansion. Check for roller support and expansion joint/loops of pipes. Similarly, the leakages from pipe joint should never be allowed to continue. As soon as a leak is noticed, it should be plugged by replacing the gasket or correcting the alignment.

iv. Care with pipe insulation: You will note that certain pipes have insulation covered with Aluminium cover (cladding). Pipelines carry hot or cold fluid. Steam line is insulated with glass wool reinforced with chicken wire mesh and cladded for long life. Similarly, chilled and refrigerant lines are covered with thermocole insulation and cladded. We must ensure proper insulation if it is found removed or not in good condition.

v. Care of valves and fittings: These are integral part of pipeline system and of different types and shapes. Valves may develop leakage either from gland of the stem or valve seat may not close the valve fully. If gland is leaky, it is repacked and lightened. The stem threads of the valve should also be lubricated if the gland is dry. The valve seat is also cleaned and grounded if seating is not proper. In most of the cases valves are replaced. Fittings, i.e., the elbow, bends, unions, flanges, sockets, tee, cross, plug, etc. help in change of direction or connection to the equipment. Usually for any defect, these are replaced.

2.10 Maintenance of basic equipment

2.10.1 Milk cans

Great care should be observed in the handling of milk cans i.e. that they are not dented or damaged more than necessary. During cleaning of cans, the cleaning solution should be kept at the proper strength as alkali or acid cleaner of high concentration remove the tin and allow rusting. Thorough drying of cans will increase their life span and also improve on milk quality handled.

Table1: Some problems and checklist to follow for the same

ITEM	PROBLEM	CHECKLIST
Vat milk temperature	Above 4-5 °C	Check if condensing units are running. Check time since milk was put in vat, and (if recorded), the temperature of the milk in the vat just as it had been put in. Check quantity of milk in vat. The vat system should cool 10,000 litres of milk at rate of 1.8 °C per hour or 5,000 litres of milk at 3.6 °C per hour.

		If time taken is excessive, call maintenance firm/engineer. If condensing units are not running, check control switches on panel. If these are on, check power supply, including low voltage control. If power is OK, check vat control unit. If no action, check fuses, if still no action, call maintenance firm / engineer.
Vat milk	Below 4 °C	Check/adjust settings on vat control unit.
Agitator	Not running when it should	Check power supply. Check settings of vat controller and control switch on panel. Check fuses. If still no action-call maintenance firm/engineer.
Milk pump	1. Not running when it should 2. Excess noise/heat 3. Milk leakage	1. Check power supply. Check starter re-set button on panel. Check fuses. If still no action-call maintenance firm/engineer 2. Call maintenance firm/engineer 3. Check cover "O" ring; tighten nuts or replace "O" ring. If leaking from adaptor housing, call maintenance firm/engineer to replace carbon seal unit.
Power	Plant not running	Check phase indicator lights (or volt meters if fitted) on panel. Check indicator light for low voltage control. If power is on and low voltage trip-out light is showing, wait for voltage to rise (get generator checked if necessary). If power is on and low voltage tri-out is not showing, wait 5 minutes. If no plant will run after 5 minutes, call maintenance firm/engineer.
All plant	Frequent resetting required	Call maintenance firm.

2.10.2 Milk cooling equipment

Various types of refrigeration equipment ranging from surface coolers, immersion coolers, ice-bank and direct expansion refrigeration systems are in use throughout the dairy industry. Whereas it is beyond the scope of this guide to go into detailed description of maintenance systems of each type of cooling system, it suffices to mention here that manufacturer instructions on service ice and scheduled repairs should be followed very strictly. Special attention should be paid to lubrication of compressors and detection and timely repair of refrigerant gas leakages.

Where brine is used as a coolant, its corrosiveness to dairy equipment should also receive particular precautions during its circulation and handling. In view of the importance of milk cooling vats in dairy industry from the producer cooperatives to the processing factories here we produced a summary of fault finding procure for direct expansion refrigeration vat:

2.10.3 Milk separator maintenance

The gears must be well lubricated; Follow manufacturer's instructions. The level of the lubricant must be kept constant; observe the oil level through the sight glass. The bowl must be carefully balanced. The bowl should be cleaned thoroughly immediately after use to ensure proper functioning of the separator and for hygiene.

2.10.4 Butter churn maintenance

The churn and butter making equipment should be washed as soon as possible, preferably while the wood is still damp in the case of wooden churns. Wash the inside of the churn thoroughly with hot water. Invert the churn with the lid on in order to clean the ventilator; this should be pressed a few times with the back of a scrubbing brush to allow water to pass though (NB: The ventilator should be dismantled occasionally for complete cleansing). Remove the rubber seal from the lid and scrub the groove. Scald the inside of the churn with boiling water or steam. Invert and leave to dry. Dry the outside and treat metal parts with food grade grease or Vaseline to prevent rusting. The rubber seal should be placed in boiling water or dipping in warm water with disinfectant is enough.

2.10.5 Milk pumps

Generally, follow manufacturer's instructions and lubrication procedures outlined above. Table 2 below gives common pump problems and possible causes.

Table 2: Common problems and possible causes

PROBLEM	POSSIBLE CAUSES
No. Liquid delivered	Delivery head too high.
	Suction lift too high
	Pump not primed - not filled with liquid.
Not enough liquid delivered	Suction line leaks air.
	Shaft seal leaks sir.
	Delivery head too high
	Suction lift too high
	Wrong direction of rat.
	Suction line smaller than pump inlet

	Air in liquid.
	Impeller channels too small.
Pump works for a while and then the flow rate is reduced	Suction line leaks air.
	Air in liquid.
	Suction lift too high.
	Impeller channels clogged.
Motor overloaded and becomes too warm	Head too low, pump flow rate becomes too high, throttle outlet or reduce impeller diameter.
	Density of liquid too high.
	Viscosity of liquid too high.
	Mechanical defects. Impeller may be rubbing against pump casing.
Pump vibrates	Cavitation
	Head much too low.
	Impeller or shaft unbalanced (shaft bent) Motor pump not properly aligned.
	Impeller channel clogged.

2.10.6 Plate Heat Exchanger

Generally, follow manufacturer's instructions and preventive maintenance programme. Pay particular attention to possibilities of under-pasteurisation, recontamination of pasteurised milk due to air leakages into the system, and milk leakages. Have in place manual product temperature indicating thermometers in addition to automatic monitors. Pay particular attention to the well-functioning of the flow diversion valve.

2.10.7 Hot Water/Steam boilers

There are basically two types of boilers; the Fire tube boilers and the water tube type. Whichever type of boiler is used, the proper functioning of the following controls and accessories are essential for efficiency and safety. Accessories like Boiler water feed pump, Oil fuel filter, Safety valves, blow down valves, Water level gauges, Low water alarms and cut-outs, Steam pressure gauges have to be regularly checked and maintained for proper economical running of the equipment. Smaller dairies now utilise hot water generators using electric coils. Whey dealing with steam

boilers or hot water generators, generally follow manufacturers' instructions and preventive maintenance programme for dairy equipment.

2.10.8 Air Compressors

Air compressors are needed in the dairy plant for operation of pneumatic valves and presses. They consist of a compressor pump, motor, air receiver and electrical controls. Generally, follow manufacturer's instructions and preventive maintenance programme. Pay particular attention to the well-functioning of the compressor and motor which are the heart of the machine.

2.11 Cleaning and sanitation

Maintenance of dairy equipment cannot be complete without due attention to its cleaning and sanitation. This is necessary not only from the hygienic point of view but also in the prevention of mechanical damage (e.g. corrosion) to plant and equipment. Selection of the right type of detergent and its proper use (temperature and concentration) is important. Generally, the cleaning procedure should consider two types of equipment, those which can be cleaned in place and those that require manual clearing.

Even for those which use CIP methods, occasionally opening up connecting ends and seals for mechanical brushing cannot be avoided. For more guidelines on proper cleaning of dairy equipment, see Processing Guide No. 1 in his series.

2.11.1 Dairy building sanitation

A clean and well-maintained dairy building and its surrounding promotes cleanliness habit amongst labour force and quality of its products. It automatically gives positive publicity and awareness to public for quality of products. A clean surrounding gives a sense of pride. A regular inspection by a team of decision makers helps in identifying the areas that need attention. It includes plant surrounding (Land Scape), condition of building, equipment and machinery, storage and warehousing, lighting, services/drains, hygiene of employees, toilets, dressing rooms, canteen, drinking water zone, insects/rodent infestation etc. There are some indicators for clean and efficient dairy plant. These will reflect how good a plant is:

- Toilets and workers amenity rooms are the first in the list. A neat and clean, well ventilated, odourless toilets indicate the level of sanitary practices in the plant. Workers dressing room be

well lighted, and should have enough space. Floors should be clean, shiny and throwing of trash behind doors or under the benches should be discouraged.

- Building premises should not harbour broken or discarded equipment/furniture. Trash and rubbish should not be thrown around that creates breeding ground for insects and rodents.
- Wall, floor and ceiling should remain clean, dry and well painted. In the dairy, light colour paints are used for walls and ceiling to reflect dirt or deposit for immediate attention. There should be proper lighting and water or dirt should not be accumulated at any point on the floor. Insects and flies should be adequately prevented entering in the milk-processing zone. Doors and window should have wire mesh covers and even air curtains should be provided. These air curtains produce thin layer of high-speed air to prevent entry of flies.
- Mould control is also important since the dairy plant uses lot of water, hence, more humidity causing moist environment. This is conducive to mould growth. To prevent this, all exposed surfaces should be kept dry. These are brushed, cleaned with soft detergent and a spray of 5000 ppm of sodium hypochloride is done. This destroys the mould spores. Further spray of quaternary ammonium compound is done to inhibit mould growth. This should be repeated every week.
- Insect and rodent control in general should be practiced. There should be no accumulation of dirt/ filth inside as well as outside. The garbage and wastes act as breeding place of insects. Good insecticide spray can be performed around the drains of dairy plant. For outdoor spray, Methoxychlor, Malathion or permitted insecticide with recommended strength could be used. All equipment is covered to avoid entry of these insects and pest. Rat proof building designs are made. Building openings are plugged. Height of the floor and steps are made such that rats cannot jump or climb. If at all, the rats find entry, they should be eliminated.

2.12 Setting up of machinery

In setting machinery, the equipment should be located, if possible, in a lighted dry place with plenty of room to work around it for cleaning and repairs. The arrangement should be that the minimum amount of sanitary piping is used, consistent with efficient operation. Related equipment may be grouped together to facilitate supervision. Straight-line flow of product is usually desirable. If possible, allow space for unit machine to be added later when the business grows.

Machines especially the heavy ones, are set directly on the floor or on concrete base and grated in thoroughly with a rich cement mixture (1 part cement and 2½ parts sand) and sufficient water. For improved sanitation, use is made of the ball foot mounting with equipment such as tanks, freezers, fillers etc, on a pipe legs 6-12 inches long having a round foot. Where machinery is bolted down, it is customary to see bolts in the concrete

3 Bibliography

0'Mahony, F Rural Dairy Technology: Experiences in Ethiopia. ILCA Manual No 4 Publ. ILCA, Addis Ababa, Ethiopia.

Ahmad Tufail. (1990). Dairy Plant Engineering and Management. Kitab Mahal Publisher

Anantakrishnan C.P. and Simha N.N. 1987. Dairy Engineering, Technology and engineering of Dairy Plant operation Laxmi Publications, Delhi

Cowan, C.T. 1983. Avoiding Corrosion and damage to Homogenisers. In: Selected case of Corrosion in the Dairy Industry. Brochures 7-11. IDF Doc. 161

Ibid. Corrosion prevention in UHT Indirectly Heat Milk Sterilisers. In: Selected cases of Corrosion in the dairy industry. Brochures 7-11. IDF. Doc 161

IDF. 1990 Handbook of Milk Collection in Warm Developing Countries. IDF Special Issue 9002.

IGNOU self-reading material (nd) http://egyankosh.ac.in/bitstream/123456789/9303/1/Unit-4.pdf

Ministry of Agriculture, Livestock Development and Marketing 1996. Dairy Equipment Maintenance. Milk Processing Guide Series (Vol 3). Training Programme for Small Scale Dairy Sector and Dairy Training Institute – Naivasha, Kenya. http://www.fao.org/ag/againfo/resources/documents/MPGuide/mpguide3.htm

Newcomer,J.L. 1981. Preventive maintenance manual for Dairy Industry Venus Trading Co. Anand, India.

*****

Processing of Milk and Value-Added Dairy Products

Latha Sabikhi[1], Gaurav Kr. Deshwal[2], P. Narender Raju[3], Shaik Abdul Hussain[2], Ashish Kumar Singh[4]

[1]Principal Scientist & Head, [2]Scientist, [3]Scientist (Senior Scale), [4]Principal Scientist
Dairy Technology Division, ICAR-National Dairy Research Institute, Karnal

Market milk processing involves several unit operations and they are discussed one by one in the following section.

1. Filtration:

Milk passes through filter to remove visible, foreign particles. These visible foreign particles reduce acceptability of the product and have an adverse effect on sale and consumption of milk. Ideally milk should be free from dust, dirt and other foreign particles. Under practical conditions it is very difficult to achieve as it involves millions of animals and milk handlers being involved in milk production and collection chain. Therefore, practical solution is to filter the milk before pasteurization.

Various kind of filters have been adapted to filter the milk, such as

- Cotton fabric-based filter paper with desired pore size. Eg: Muslin cloth
- Plastic sieve and Plastic filter (Nylon filters)
- A frame or support to hold the outer margin of the cloth
- Filter assembly (manifold) in which filter cloth / pod is assembled over the support of perforated metal plates.

Recently product distributor has been used to uniformly distribute the product for multiple filtration system, it distribute the product among the filters and thus minimizes the tearing of the filter cloth / sheet. The filter cloth / sheet should be placed in such a way that, it should be easily accessible for cleaning and for replacement. Duplex filter system will be used in continuous HTST pasteurization and in UHT treatment. In this, one set of filer acts as standby while other set is being in use. Usually 100 to 150micron pore size filters are used to filter the milk and some time as low as 60micron pore size filters are also used for this purpose.

2. Cream Separation:

Cream separation is the process of removing fat from the milk. Milk as discussed earlier contains fat and solids not fat (SNF) in it. Fat from the milk is separated in the form of cream. The cream in dairy is used to standardize the milk to desired fat level, to prepare butter, to prepare ghee, to prepare ice cream and also to manufacture various cream products like table cream, whipped cream etc. Fat in milk is present in the form of globules and dispersed in aqueous phase therefore it is termed as fat-in-water emulsion. Fat globules size of bovine milk varies from 0.2 to 20 micron. Fat globule is surrounded by fat globule membrane (FGM) and its size varies from 10-20 nm. FGM majorly contains proteins, which protects the central fat core. It also contains some proteins which is responsible for clustering of fat globules together. The density of fat and SNF is different in milk, this difference facilitates the separation of fat from SNF portion of milk. The density of milk fat is 0.93 kg/l and it is lighter than the density of SNF (1.036 kg/l) of milk. If milk is kept undisturbed for several hours, the lighter portion of milk, i.e. milk fat starts moving towards the top due to difference in density. This effect is due to the gravitational force and difference in density.

Application of centrifugal force in cream separation:

The rate of milk fat separation can be magnified by employing centrifugal force. As compared to natural creaming centrifugal separation is quicker, more hygienic and complete fat can be removed from the milk.

Cream separators are designed to create the centrifugal force, this force usually 6000 to 10000 times higher than the gravitational force. From the above equation, it is evident that in addition to density differences between fat and SNF and diameter of the fat globule, number of disc in the cream separator and the distance of fat globule from axis of rotation have directly influence the velocity or separation rate of fat globule in centrifugal separator.

Centrifugal Milk Separator: Various types of cream separators are available in market. Based on design, there are three types of cream separators:

Open type separator: It was the first design and presently restricted to laboratory model. It consists of two major parts namely body and the hood. They are held by thread lock ring. Discs are stacked together at a 45 to 60 degree angle and separated by a 0.4 to 2.0 mm gap. This gap is

maintained by distance spacers, welded on upper surface of disc, but lower disc have the distance spacer on both the surfaces. Disc holes lay one over the other and form channel for the milk. The discs are generally made of stainless steel with a thickness of approximately 0.4mm. The milk enters the machine along the central axis and flows into the revolving bowl through milk distributor which has three or more openings. Above these openings, disc channels are formed and have space for milk to enter between the discs. The centrifugal force drives the fat globules in the space between the discs from where they move upwards and inwards in the form of cream. The skim milk, being heavier than milk fat moves outwards. Then these two streams are started moving towards top of the equipment as two separate streams and collected separately.

Semi-Open type centrifugal separator: Open type separators discharge the separated liquid(s) through overflow ports, therefore it has limitation of foaming while separation. Centrifugal separators with paring disc at the outlet are known as semi-open type. In the semi-open separator, the milk is supplied to the separator bowl from an inlet, normally in the top, through a stationary axial inlet tube. Cream and skim milk collected through separate channels enter the paring disc where kinetic energy of the liquid is converted into pressure energy, enabling pressurized discharge. Paring disc remain covered by a liquid and limit the entrainment of air.

Hermetic type centrifugal separator: Hermetic separators are more commonly chosen by milk processor of recent time. This is similar in design to semi-open separator, and additional seals are used to ensure the product is enclosed within the separator and isolated from atmosphere. An automatic constant pressure unit for a hermetic separator is fixed at the skim milk outlet. The required product pressure is adjusted by means of compressed air above the diaphragm. During separation, the diaphragm is affected by the constant air pressure above and the product (skim milk) pressure below. The preset air pressure will force the diaphragm down if the pressure in the skim milk drops. The valve plug, fixed to the diaphragm, then moves downwards and reduces the passage. This throttling increases the skim milk outlet pressure to the pre-set value. The opposite reaction takes place when there is an increase in the skim milk pressure, and the preset pressure is again restored.

Efficiency of cream separator:

The efficiency of a separator in removing fat from milk is generally measured by the fat content of resultant skim milk. The centrifugal cream separator can recover almost 99% of the total fat in milk under normal operational conditions. Many cream separators in commercial usage produce skim milk containing not over 0.01% fat. The percentage of fat loss can be calculated by following formula;

Factors affecting the efficiency of separation:

- **Temperature of milk**: Lower temperature increases the viscosity of the milk thus slower the movement of fat globules and also the cold cream has a tendency to stick to the bowl parts and move slowly towards the cream outlet resulting in clogging of the separator. A temperature in range of 40 to 50°C is required for higher efficiency of separation.
- **Speed of separator bowl**: The speed of the bowl determines the amount of centrifugal force generated. At lower speed, the centrifugal force generated is lower, hence all the milk will not be subjected to centrifugal force and the net result is incomplete removal of fat from the milk.
- **Rate of inflow of milk**: If milk travels through the separator too rapidly, it is subjected to centrifugal force for a very short time, hence complete removal of fat becomes impossible. The rate of flow should be so adjusted in such a way that all the milk entering the bowl be subjected to centrifugal force.
- **Fat globule size**: Higher the diameter of the fat globule, greater will be the efficiency of separation.
- **Mechanical condition of machine**: The badly worn discs result in incomplete removal of skim milk and cause remixing with cream thus affecting efficiency of separation. The other reason of reduced efficiency could be improper installation and leveling of the machine. Improperly installed or leveled machine causes vibration of the bowl. This may result in remixing in the stream of cream and skim milk at some point during separation process, hence reduces the efficiency of separation.
- **Slime accumulation**: Sediment consists of udder cells, white blood cells, red blood cells, bacteria etc. will be collected in a sediment space of the separator bowl. The amount of slime is generally in the tune of about 1kg per 10,000 liters of milk. Over accumulation of slime in the bowl reduces the space between the bowl wall and the disc stack and result in remixing of

flow of skim milk and cream thus reducing the efficiency of separation. Therefore, frequent removal of slime is necessary. Most of the recent cream separator designs have automatic slime ejection system.

3. Homogenization:

The fat in milk occurs in the form of globules varying in their size from 0.1 to 20 µ. Such wide variation in globule size and the lower density causes formation of cream layer when the milk is left undisturbed. Homogenisation of milk is a mechanical process whereby the fat globules are broken up to such an extent that they do not rise to the surface to form cream layer. The milk is forced through a narrow slit (passage) at high velocity and pressure in order to disintegrate original fat globule in milk and reduce their size to 1µ or less. The fat globule membrane become deformed, then become wavy and then break up due to high shearing stresses, cavitations & micro turbulence. The newly formed fat globule is devoid of its original membrane and instead is covered with mixture of proteins adsorbed from the serum phase of milk. The process of homogenization was invented by "Gualin" in 1899. Today it is a standard industrial process which is practiced universally. Homogenization involves physical changes in milk proteins resulting in lower curd tension that increases digestibility of homogenized milk and products made from such milk.

Effect of Homogenization: The fat globules of milk are surrounded by a membrane 5 to 10nm thick. The membrane has properties of an emulsifier and keeps the emulsion of milk stable. During homogenization the original membrane is destroyed and the first result is rise in interfacial tension. However surface active agents form a new membrane by adsorption and interfacial tension soon fall again. The new emulsion remains stable even after homogenization.

Advantages:

- Smaller fat globules leading to no cream line formation
- Make whiter colour in milk
- Reduces the sensitivity to fat oxidation
- Improves body and flavour
- Provides better stability to the products made out of homogenized mlk like cultured milk
- Increases viscosity of milk

Disadvantages:

- Milk will not be suitable for semi-hard and hard cheese manufacturing because of soft coagulum.
- Increases the sensitivity to light induced changes in milk
- It hampers the separation efficiency

The effect of homogenization is produced by three collaborating factors,

a) Shearing stresses generated due to high velocity

b) Cavitation effect due to sudden drop of the pressure below the vapour pressure of the fat

c) Shattering effect, happens when the fat globules impact at high velocity on impact ring.

Homogenization Operation:

The product enters the pump and is pressurized by the piston pump. The distance between the forcer and the valve seat determines the pressure in the homogenization chamber. Piston pump boost the pressure of milk from 3 bar at the inlet to a homogenization pressure of 100 to 250 bar depending on the product. The pressure can be read on pressure gauge. Deformation and size reduction of fat globules happens in the first stage of homogenization. Second stage of homogenization facilitates a constant and controlled back pressure to first stage for best possible condition of homogenization and also breaking up of clusters formed directly after homogenization. A 20 to 50bar pressure will be maintained in the second stage. Two-stage homogenization is not always necessary. Second stage is used, only if the fat globules have the tendency to agglomerate after the first stage of homogenization. Whenever, the two stage homogenizer is operated second stage pressure adjustment to be done first followed by first stage pressure adjustment. Milk is supplied at high pressure to the space between the seat and the forcer. The width of the gap is approximately 0.1mm. The velocity of the liquid is normally 100 to 400m/s in the narrow annular gap. Homogenization takes place in 10 to 15 microseconds. During this time the pressure energy delivered by the piston is converted into kinetic energy. Part of the pressure energy is again converted back to pressure energy and another part will be released as heat energy.

Various Parts of homogenizer:

- **Homogenizer pump**: This does the job of pumping the milk to homogenization chamber. It is a plunger type positive displacement pump works with piston, 3 to 5 piston pumps are very

common in industry. Increasing the number of pistons decreases the degree of pulsation and maintains uniformity in the flow.

- **Homogenizing valves**: These valves are made up of Tungsten Carbide, tungsten- cobalt or stellite alloy material, which can withstand very high pressures.
- **Inlet strainer**: Inlet strainer is placed in the suction line of the homogenizer pump and its function is to prevent the coarse particles and other particles from entering the pump. The strainer is fitted with removable perforated metal screen.
- **Pressure adjusting knob and pressure gauges**: They are to adjust the homogenization pressure of the first and second stage, separate pressure adjustment knobs and pressure gauges are provided for both the stages. Pressure gauges read the pressure from the respective stage of homogenization and may be of the analogue or digital type.

Homogenization efficiency:

The effect of homogenization is frequently expressed in terms of the mean droplet diameter of the disintegrated fat globule. However other analytical methods developed were also used to measure the efficiency of homogenization. NIZO developed the method in which homogenized milk sample of 25ml is centrifuged at 1000rpm for 30min. the ratio of fat % present in 20ml sample of lower side to fat % of the top 5 ml sample multiplied by 100 gives the efficiency and values with more than 80% indicates good homogenization.

Power requirement:

E=power requirement P=homogenizing pressure V=volume of flow. V=100l/h=1m3/h

P=250kg/cm3= 25X105kg/m2

E=p.v

E= 25X105kg-m/h / 3600X75 = 9.26

1hp=75kg-m/s

Processing of raw milk to prepare TM / DTM / STDM / SM / FCM:

Processing of raw milk includes several operations to be given to it, in order to make it safe for human consumption and to meet the legal requirements. Processing also improves the physico-chemical and microbiological quality of the product. These operations include filtration, separation, standardization, homogenization, pasteurization and sterilization. Most of these

operations are synchronized with the HTST pasteurizer, thereby facilitating a continuous process operation.

In India milk production is scattered and mostly restricted to small and medium scale farmers who are holding one or few animals. Raw milk (unprocessed milk) is collected from these farmers (also referred as milk producers) by village cooperative society or private entrepreneurs. Milk is then pooled and chilled at chilling centre or at main processing plant, whichever is closer. Chilled milk is then stored in the raw milk silo for further processing.

In the processing plant, raw milk is pumped from raw milk silo to float controlled balance tank (FCBT) of pasteurizer unit using stainless steel pump of suitable capacity. Milk then passes to regenerative heating section-I of pasteurizer, wherein milk is heated from 5°C to 40°C. At this temperature, milk is routed to the filter assembly for filtration. Filtration is carried out using duplex filter unit, in which one filter is usually kept as standby to facilitate continuous processing during cleaning operations. After filtration, milk passes into the cream separator. Several types of separators are available, among which, those with online standardization units help to standardize the milk to desired fat level. Otherwise, milk needs to be standardized to desired fat and SNF level before taken into HTST pasteurizer for production of toned, double toned milk etc. After separation and/or standardization, milk moves back to pasteurizer for further heating. Milk is then heated from 40°C to 65°C in regenerative heating section-II and then taken out for homogenization. Homogenization is suitable for high fat milk, wherein milk fat size reduces to less than two micron size and thus reduces the cream plug formation during the storage. Cream plug formation occurs due to the difference in density of fat and SNF. Homogenization also brightens the colour of milk due to more scattering of light and reduces the curd tension, thereby improving the digestibility of milk. After homogenization, milk is again moved back to pasteurizer for further heating. Milk is heated to final pasteurization temperature of 72°C or higher in heating section using hot water as heating medium. After heating section, milk moves to the holding section, wherein it is held at temperature not less than 72°C for 15 seconds. At the end of the holding section, flow diversion valve (FDV) is fixed to verify whether each and every particle has reached the pasteurization temperature or not. If any part of milk has not attained the pasteurization temperature, FDV diverts that part of milk to FCBT for reprocessing, thus ensuring the safety of pasteurized milk. Properly heat treated milk moves back to regenerative cooling section-II and

then regenerative cooling section-I and finally chilled to less than 5°C in chilling section. Chilled water is used as cooling medium in chilling section. Minimum back pressure is necessary in heating section to prevent boiling of milk. It should be higher than the pressure of heating medium or chilling medium in pleat heat exchanger to avoid any risk of cross contamination.

Chilled milk is stored in pasteurized milk silos, from where it is transferred to packaging section after ensuring its safety and quality parameters. The production flow chart that may be used for pasteurized toned, double toned and standardized milk is given in Fig. 1. Standardization of fat and SNF is the only difference among the different types of market milk. During standardization, the milk fat is removed if it is excess than desired and added in the form of cream to milk, if it is less. Similarly SNF is also standardized to desired level by adding skim milk or skim milk powder (SMP) in case of shortage. Excess SNF can be adjusted by adding milk of low SNF than is desired.

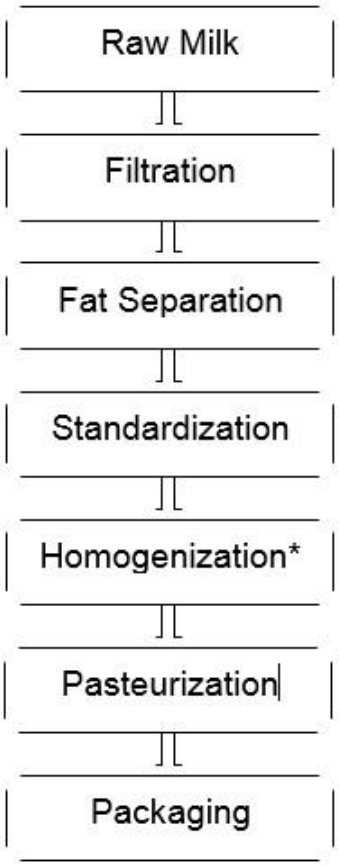


Fig. 1. Flow chart for the production of toned, double toned and standardized milk

NOTE: * Homogenization is optional for low fat products like DTM/TM and applicable in high fat milk like STDM/FCM

Sl. No.	Type	Fat (%)	SNF (%)
1	Toned Milk (TM)	Minimum 3.0	Minimum 8.5
2	Double-toned milk (DTM)	Minimum 1.5	Minimum 9.0
3	Standardized milk (STDM)	Minimum 4.5	Minimum 8.5
4	Skimmed milk (SM)	Not more than 0.5	Minimum 8.7
5	Full cream milk (FCM)	Minimum 6.0	Minimum 9.0

Apart from the above-mentioned types, there are five more categories such as cow milk (3.2% fat and 8.3% SNF) buffalo milk (6.0% fat and 9.0%SNF), goat / sheep milk (3.0-3.5 % fat (variable across different states) and 9.0 % SNF), camel milk (2% fat and 6% SNF) and mixed milk (4.5% fat and 8.5% SNF).

Production of reconstituted milk

The term reconstituted milk is used when milk is prepared from the dry powder or milk powder. It may be prepared from either SMP and/or whole milk powder (WMP). There are no preset standards for reconstituted milk. However, it should meet the other appropriate general standards of SM/TM/DTM/STDM after reconstitution. The schematic diagram of reconstitution process is shown in Fig. 2. The milk powder is dissolved in lukewarm water at 40°C in a double jacketed vat equipped with an agitator for uniform mixing of the contents. The heating medium circulated in the jacket is usually hot water. Dry powder is added through venturi system. Water being a major raw material for reconstituted milk, the water quality which is used for dispersion of milk powder is important and should be checked routinely for its chemical and physical quality parameters. It must also be free from harmful microorganisms. Soft water is preferred because high mineral content in water disturbs the colloidal stability of milk at high temperature processing during later stages. After addition of powder into water, contents are recirculated and agitated till complete dissolution of powder. The complete hydration of milk powder is very much essential in order to prevent chalkiness (a defect) in the finished product. The hydration time varies with the powder quality. Good quality powder must hydrate completely within 30 minutes. After complete hydration, reconstituted milk is transferred to float controlled balance tank of the pasteurizer for heat processing. The pasteurized reconstituted milk is stored in pasteurized milk storage tank till its packaging. At commercial level, reconstituted milk is used only for standardization purpose.

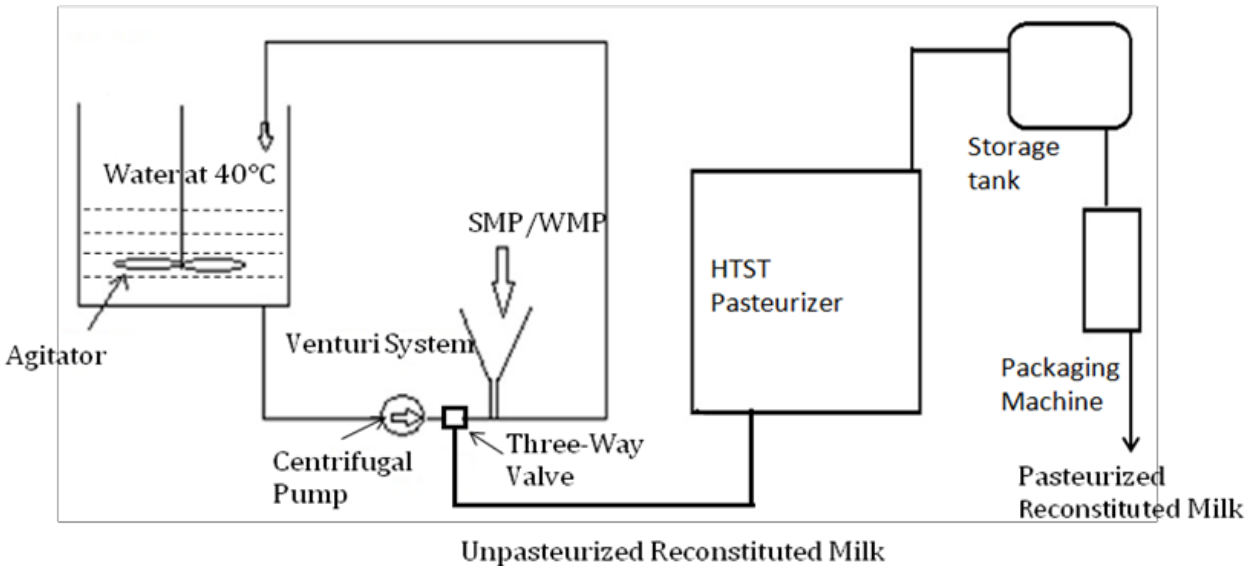


Fig. 2. The schematic diagram of reconstitution process

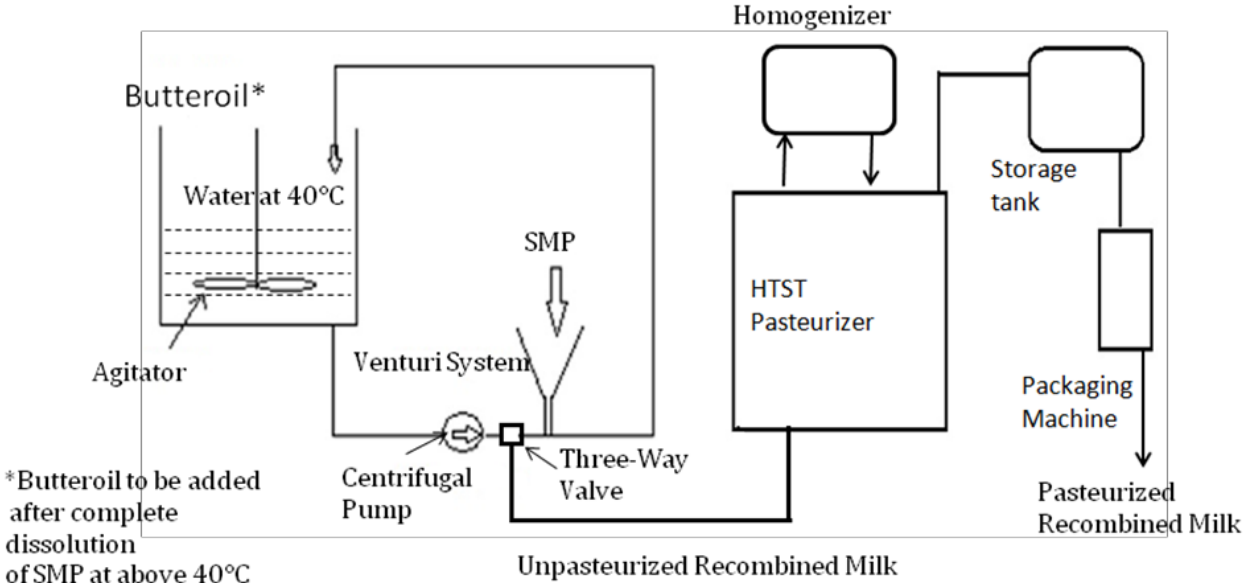


Fig. 3. Schematic line diagram of recombined milk processing

Production of recombined milk

According to FSSR-2011, recombined milk is defined as the homogenized product prepared from milk fat, non-fat-milk solids and water. The recombined milk shall be pasteurised and shall show a negative phosphatase test. It should have minimum 3.0% fat and 8.5% SNF. The scarcity of fresh

milk in lean season is the reason for production of recombined and reconstituted milk so as to meet the market demand. This also helps to utilize the milk solids that get converted and stored in the form of SMP, WMP, butter and butteroil due to excess collection of milk during the flush season. Recombined milk can be produced in hilly areas and other places where there is limited availability of raw milk. The milk fat sources for recombined milk are generally butter oil or anhydrous fat and/or unsalted butter. Therefore, homogenization is an essential step in preparing recombined milk since fat source is added into the water. The solids-not-fat source dissolves easily in water, but the fat source needs homogenization to disperse in the water.

Homogenization helps in creating an oil-in-water emulsion that is native to milk. The schematic diagram of reconstitution process is shown in Fig. 3. Homogenization is done at 65°C in a two stage homogenizer at a pressure of 150 kg/cm2 and 50 kg/cm2 in first and second stage respectively. Therefore milk is heated to 65°C in the HTST pasteurizer and routed from the regeneration section out into the homogenizer at this temperature. After homogenization, milk is again goes back to HTST pasteurizer for completing the pasteurization.

Flavoured Milk

It is a special type of milk produced to attract the consumers, particularly children. Flavoured milk generally contains sugar, permitted food grade flavors and colours. The product is heat treated in order to ensure its safety to consumers and also to extend the keeping quality. Flavoured milk is marketed as pasteurized flavoured milk packaged in low density polyethylene (LDPE) pouches, ultra-high temperature (UHT) treated flavoured milk packaged aseptically in a multi-layer laminates and sterilized flavoured milk packaged in glass or retortable plastic bottles. Pasteurized flavoured milk has a limited shelf-life of two days at refrigerated temperature, whereas UHT treated and sterilized flavoured milk will stay safe for 4-6 months at ambient temperature. Sugar, suitable colour and flavours are added to increase the flavor and appearance of the product. The commercial products are available in a variety of flavours such as rose, elaichi (cardamom), badam (almond), strawberry or butterscotch.

FSSR-2011, prescribes the standards to flavoured milk in terms of fat and SNF. Flavoured milk shall meet the minimum fat and SNF level of double toned milk/ toned milk/ standardized milk. Therefore, manufacturer has to clearly declare the type of milk on its label. Flavoured milk may

also contain nuts, coffee, and chocolate in addition to cane sugar. Sugar is added at the rate of 7-8% based on the flavor. Chocolate and coffee flavoured milk requires slightly higher amount of sugar for better palatability. Only permitted and food grade colour and flavours should be used, the level varying with the type of flavor. Flavour is usually dosed at the rate of 0.1 to 0.2% level and maximum colour addition is 100 parts per million (ppm) for artificial colours. Natural colours like β-carotene is added as per requirement. Following are the various artificial colour compounds used to obtain different colours in flavoured milk.

S. No.	Colour desired	Colour compound
1	Yellow	Tartarzine
2	Red	Ponceau 4 R
3	Orange	Sunset Yellow
4	Blue	Brilliant Blue
5	Green	Tartarzine + Brilliant
6	Pink	Carmosine

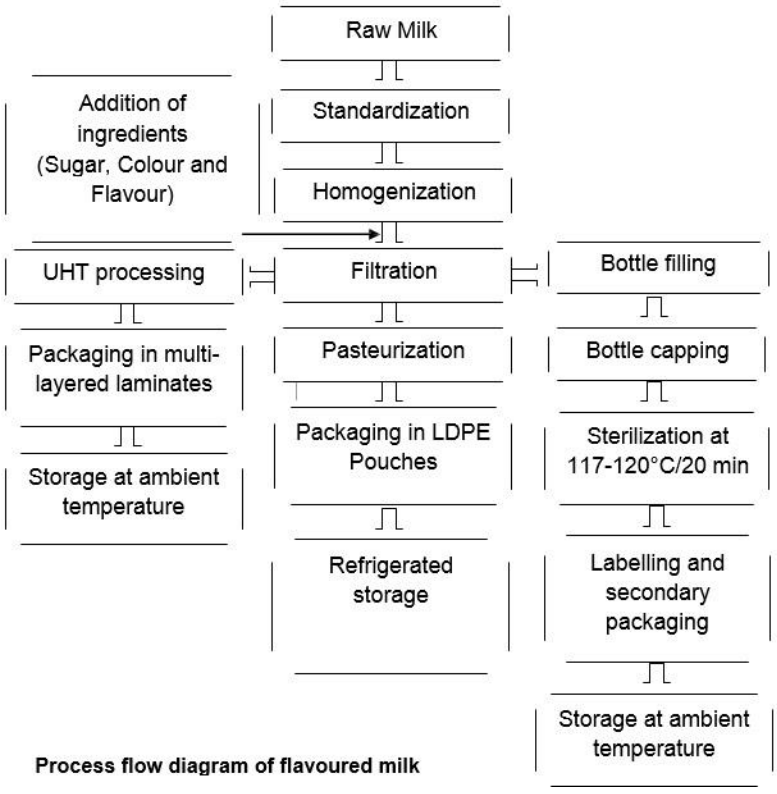


Fig. 4. Process flow diagram of flavoured milk

Pasteurized flavoured milk involves treatment like filteration, homogenization, standardization, pasteurization and packaging similar to general market milk. Milk is standardized to higher fat and SNF levels so that when sugar and other ingredients are added later fat and SNF level meets the desired level. Standardized milk is then homogenized in two stage homogenizer to avoid cream plug or cream layer formation during the storage of the product. The detailed process flow diagram is given in Fig. 4. After, mixing with other ingredients like sugar, flavor and colour, the milk is filtered and pasteurized at slightly higher temperature than the market milk. The pasteurization treatment is usually at 76-78°C/ 15 seconds, with immediate cooling thereafter to 4°C. The pasteurized flavoured milk is then packaged in the form-fill-seal (FFS) machine in the form of 200 ml or 500 ml pouches and stored at refrigerated temperature.

Sterilized flavoured milk is prepared to extend the shelf life of the flavoured milk, steps are similar to pasteurized flavoured milk till filtration. Thereafter, flavoured milk is filled into the bottles of 200 ml capacity and capped. These bottles are placed on the trolley of the retort sterilizer and sterilized at temperature of 117-118°C for 20 minutes. Steam is used as the heating medium for the retort sterilizer. After sterilization, bottles are allowed to cool to room temperature, labeled and packed in secondary package (cardboard trays) for distribution and transportation. UHT treated flavoured milk is also prepared in the same manner, except here the product is expose to high temperature like 135 to 140°C for few seconds and packaged aseptically in a multi-layered cartons.

Butter Manufacturing Technology

Butter is water in oil type of emulsion and has quite complex structure. The continuous phase of free fat in liquid form holds the water droplets as dispersed phase due to the semi-solid nature of the continuous phase. The steps in the manufacture of butter begin with the separation of cream (to around 30-40 % fat) from the pasteurized milk by centrifugation. This is followed by keeping and maintaining the cream at a low temperature for aging. Aging results in the optimum liquid to solid fat ratio in the butter. This may alternatively be done by inoculating the cream with lactic acid producing microorganisms and ripening at 14°C for 20 h so as to develop the desired flavor.

Butter is manufactured from this cream. In the batch process (Fig.5), this cream is tumbled inside the hollow vessel called churn. The cream is churned as a result of which air gets incorporated in

the cream and fat globules concentrate on the surface of the air bubbles. As a consequence of this repeated breaking and reforming, some of the fat globules break open and release the free fat, while others form clumps, generally known as butter grains. These butter grains are held together by the free fat. The churning is continued and a stage is reached when these grains grow in size and reach an optimum size of around 1 cm in diameter. At this point, churning is stopped and the aqueous phase i.e. buttermilk is drained off. The grains are washed with chilled water of the equal quantity as that of the drained buttermilk. This is done so as to facilitate the removal of more of curd from butter. The product thus obtained is called white butter.

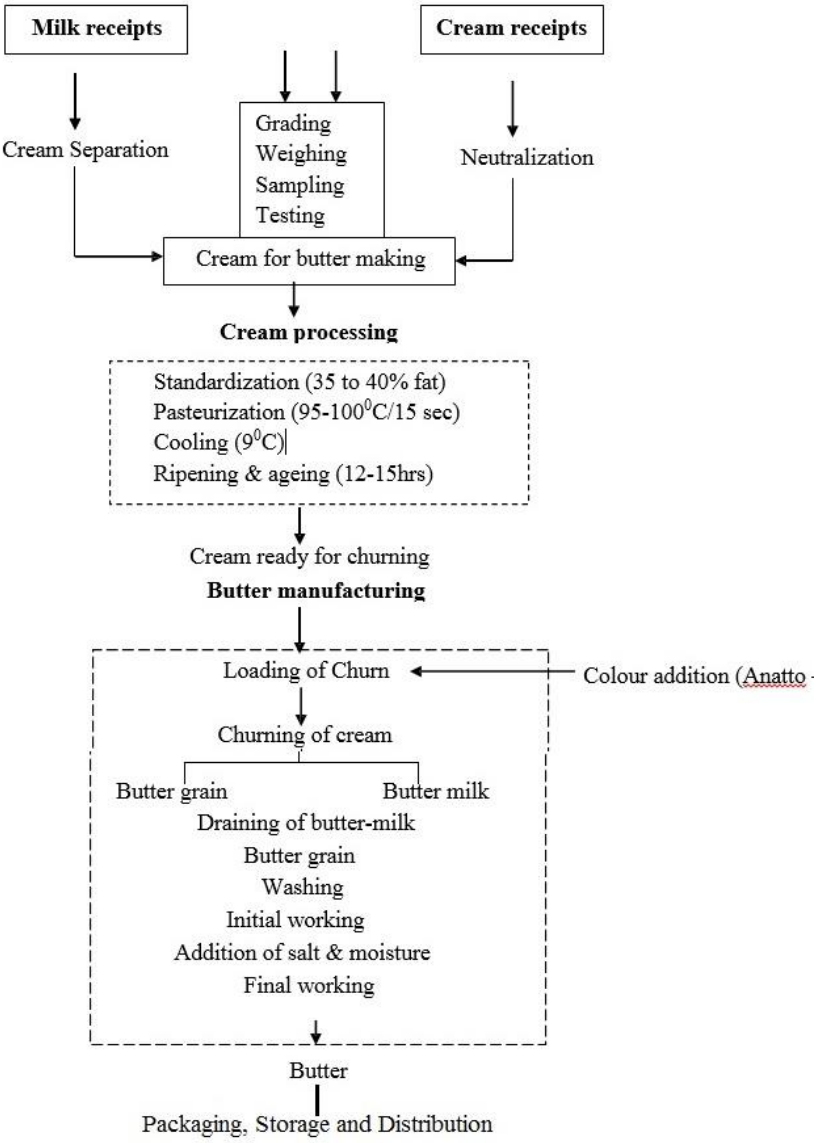


Fig.5. Flow diagram for the preparation of butter.

For the preparation of table butter, moisture is adjusted and salt is added. The mass is again worked in the churn for a further period. During this step of working, more of the fat globules break leading to release of more free fat. Water droplets and salt crystals are thoroughly dispersed in the bulk of the fat phase and the texture of the product develops. By carrying out working under the partial vacuum, the air content of butter may be reduced. After working is completed, approximately 40 % of the fat remains as globular. The butter is then discharged from the churn, packaged and transferred to chilled or frozen storage.

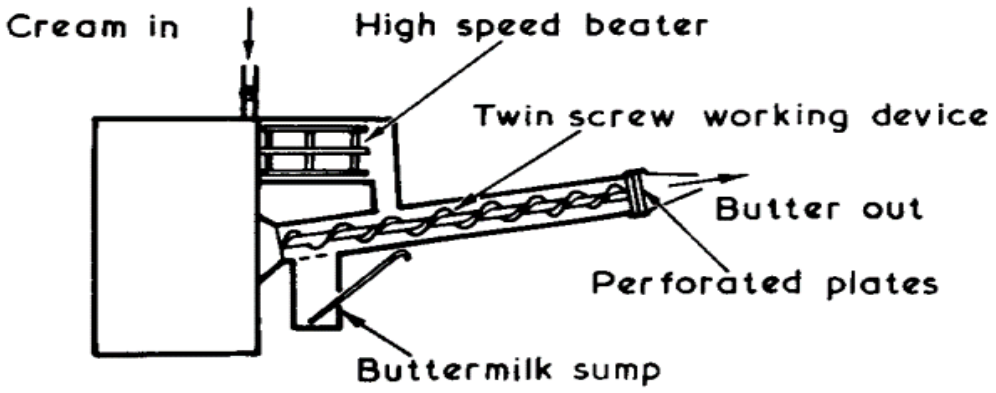


Fig. 6. Continuous churning of cream

In the continuous method of butter making, the principle is the one depicted in the Fig. 6. The aged cream (around 30-40% fat) as obtained previously is acted upon by the high-speed beaters in the churning section of the equipment. After the formation of butter, both butter grains and buttermilk leave the churning section- buttermilk drains into the sump, while grains are carried by twin screws up the sloping barrel and extruded through a series of perforated plates. As a result of the action of screw and perforated plates, further disruption of fat globules takes place and also the remaining water is dispersed as droplets throughout the fatty phase. Butter is finally extruded as a continuous ribbon from the working section. For the preparation of table butter, salt may be added in the working section.

Critical Control Points/ Operational Pre-Requisite Programs are:

1. RO water pasteurization temperature (NLT 76°C for 15 seconds)
2. Butter cold storage temperature (NMT4°C)
3. Online metal detector

Mozzarella Cheese Manufacture

Mozzarella cheese was originally manufactured from high fat buffalo milk in the Battipaglia region of Italy, but it is now made all over Italy, in other European countries and USA from cow milk. It belongs to the cheese classified as "pasta filata" which involves the principle of skillfully stretching the curd in hot water to get a smooth texture and grain in cheese. It is a soft, white un-ripened cheese which may be consumed shortly after manufacture. Its melting and stretching characteristics are highly appreciated in the manufacture of Pizza where it is a key ingredient. The method of manufacture of Mozzarella cheese, irrespective of the milk system from which it is made involves (1) optimum addition of starter culture or proper acidification of milk, (2) renneting of milk, (3) cutting the curd at the right firmness, (4) stirring and cooking the curd particles to the correct consistency and (5) proper cheddaring, stretching and salting of curd for optimum plasticity and elasticity.

Chemistry of "stretch" of Mozzarella cheese

In the calcium rich environment of milk, the casein precipitates out of milk as di-calcium paracaseinate, entrapping fat, insoluble minerals and some sugar. At a pH between 5.2-5.4, resulting from the development (or direct introduction) of acid, some of the calcium of the dicalcium paracaseinate gets dissolved, leading to the formation of monocalcium paracaseinate. This when heated to 54°C or higher becomes smooth, pliable and stringy and retains fat. If acidification is excessive, generally below pH 5.2, monocalcium paracaseinate will continue to lose calcium and from paracasein, which may stretch, but has difficulty in retaining fat. The curd generally does not stretch above pH 5.6.

An ideal Mozzarella cheese has a smooth surface with a perfect sheen, elastic, stringy body free from mechanical openings. The process flow diagram for the production of traditional and direct-acidified mozzarella cheese are given in Fig. 7 and Fig. 8, respectively.

Milk
↓
Filtration/ Clarification
↓
Standardization (3-4% fat)
↓

Pasteurization (63°C/30min.)

↓

Cooling (31°C)

↓

Starter addition (S. thermophillus and L. bulgaricus (1:1) @ 1-2%)

↓

Rennet addition (1.0- 1.5 g/100 l.milk)

↓

Cutting

↓

Cooking (42-44°C)

↓

Pitching

↓

Draining

↓

Cheddaring (0.70% acidity)

↓

Milling

↓

Plasticizing / stretching under hot water (80-85°C)

↓

Molding

↓

Brining (20-22% Chilled Brine)

↓

Packaging

↓

Storage

Fig. 7. Traditional method of manufacturing Mozzarella Cheese

Milk

↓

Filtration/ Clarification

↓

Standardisation (3-4% fat)

↓

Pasteurization (63°C/30min.)
↓
Chillling (4-8°C)
↓
Acidifying
(To pH 5.4- 5.6 with 25-50% HCl @ 2.0-3.5 ml. conc. acid/l.milk)
↓
Heating (28-30°C)
↓
Rennet addition (0.5-0.75 g./100 l.milk)
↓
Cutting
↓
Cooking (37-390C)
↓
Draining
↓
Plasticizing/ stretching under hot water (80-85°C)
↓
Molding
↓
Brining (20-22% chilled brine)
↓
Packaging
↓
Storage

Fig. 8. Direct Acid method of manufacturing Mozzarella Cheese

Advantages of the Direct Acidification Technique

1) Curtailed manufacturing time and expenses
2) Simplified technology due to elimination of propagation and maintenance of starter cultures
3) Starter failures due to bacteriophages and antimicrobial agents avoided
4) Less rennet required
5) Amenable to mechanization

Disadvantages

1) Slight reduction in yield of cheese
2) Bland flavour

Defects:

Defect	Cause
Marbling	Incomplete stretching or mixing, too low water temp., low acidity of curd or a combination of these
Poor melt ability	High salt content
Discoloration	High salt content
Yoghurt flavour	High acetaldehyde production
Browning defect on Pizza top	Use of *Streptococcus salivarius* subsp. *Thermophilus* that do not ferment galactose
Abnormal gas prod., changes in texture and aroma	*Propionibacterium freudenreichii*
Pigmentation, hole formation, texture changes, off-flavour and aroma in direct acid cheese	*Pseudomonas, Achromobacter, Acinetobacter, Citrobacter, Enterobacter, Escherichia, Serratia*
Superficial red brown marks, putrid smell, distinct bitter flavour	*Pseudomonas putida, P. flourescens, P. palloroni*
Soft body → poor slicing, melting	*Lactobacillus* casei

Ice Cream and Frozen Desserts

Ice cream is a frozen dairy product made by suitable blending and processing of cream and other milk products, together with sugar and flavour, with or without stabilizer or colour, and with the incorporation of air during the freezing process. The broad term frozen desserts refers to ice cream and related products. There are many varieties of ice cream available which may differ in flavour, colour, form or ingredients. Ice cream comprises a mixture of air, water, milk fat and solid not fat, sweeteners, stabilizers, emulsifiers, flavours and colours. All the ingredients are mixed and processed to form ice cream mix and this mix is then frozen as fast as possible with incorporation of air. This process forms ice cream in semi frozen state which is then hardened to freeze it further.

Definition and standards

According to Food Safety and Standards Regulation, 2011, Ice Cream, Kulfi, Chocolate Ice Cream or Softy Ice Cream means the product obtained by freezing a pasteurized mix prepared from milk

and/or other products derived from milk with or without the addition of nutritive sweetening agents, fruit and fruit products, eggs and egg products, coffee, cocoa, chocolate, condiments, spices, ginger and nuts and it may also contain bakery products such as cake or cookies as a separate layer and/or coating. It may be frozen hard or frozen to a soft consistency; it shall have pleasant taste and smell free from off flavour and rancidity. It may contain food additives permitted in this regulation and it should also conform to the microbiological standards laid by the regulation. The product shall conform to the requirements given below.

Table: FSSAI standards for Ice cream

Requirement	Ice Cream	Medium Fat Ice Cream	Low Fat Ice Cream
Total Solid	Not less than 36.0 percent	Not less than 30.0 percent	Not less than 26.0 percent
Wt/Vol (gms/l)	Not less than 525	Not less than 475	Not less than 475
Milk Fat	Not less than 10.0 percent	More than 2.5 percent but less than 10.0 percent	Not more than 2.5 percent
Milk Protein (Nx6.38)	Not less than 3.5 percent	Not less than 3.5 percent	Not less than 3.0 percent

(The Food Safety and Standards Regulation, 2011)

Note: In case where Chocolate, Cake or similar food coating, base or layer forms a separate part of the product only the Ice Cream portion shall conform to the requirements given above. The type of ice-cream shall be clearly indicated on the label otherwise standard for ice-cream shall apply.

Frozen Dessert/Frozen Confection means the product obtained by freezing a pasteurized mix prepared with milk fat and/or edible vegetable oils and fat having a melting point of not more than 37°C in combination and milk protein alone or in combination/or vegetable protein products singly or in combination with the addition of nutritive sweetening agents e.g. sugar, dextrose, fructose, liquid glucose, dried liquid glucose, maltodextrin, high maltose corn syrup, honey, fruit and fruit products, eggs and egg products, coffee, cocoa, chocolate, condiments, spices, ginger and nuts. The product may also contain bakery products such as cake or cookies as a separate layer or coating; it may be frozen hard or frozen to a soft consistency. It shall have pleasant taste and flavour free from off flavour and rancidity and may contain permitted food additives. It shall also conform to the microbiological requirements prescribed in the regulation. Total solids, weight /volume and other specifications for frozen desserts are same as for ice cream (The Food Safety and Standards Regulation, 2011).

Method of manufacturing Ice cream

The method of ice cream making can be divided into two phases viz. ice cream mix preparation and freezing of ice cream mix. For mix preparation, firstly all the ingredients are selected based on the composition, type and quality of ice cream desired. The selected ingredients are then proportioned, blended together, pasteurized, homogenized, cooled and then kept for ageing. Properly aged mix is then frozen in ice cream freezers, packaged in containers of desired size and kept for hardening. All these steps will be discussed in detail in the following section. Fig. 9 represents a brief outline of the process of ice cream making.

Selection of ingredients
↓
Formulation of ice cream mix
↓
Blending
↓
Pasteurization (Batch: 65°C/30 min, Continuous: 80°C/ 25 sec)
↓
Homogenisation (First stage: 2500 psi, Second stage: 500 psi)
↓
Cooling (0-4°C) Ageing (3-4 h)
↓
Freezing the mix (-4 to -5°C)
↓
Packaging
↓
Hardening (-23 to -29°C) Storage

Fig: 9 Flow diagram for ice cream processing

Selection of ingredients

Selection of good quality ingredients is a pre requisite for making good quality ice cream. Ingredients for ice cream making can be divided into two group namely dairy ingredients and non-dairy ingredients. Dairy ingredients are the sources of fat and milk solid not fat required for imparting a characteristic richness and flavour to ice cream. These ingredients also contribute to smoothness of texture and resistance to melting. Various sources of milk fat and SNF are milk, cream, unsalted butter, skim milk powder, sweetened condensed milk etc. Non-dairy ingredients

include sweeteners, stabilizers, emulsifiers, eggs and egg product, flavours and colours etc. All these ingredients impart numerous functional properties to ice cream mix.

Formulation of ice cream mix

For making good quality ice cream and also to conform to legal standards, composition of ice cream mix is decided and according to the desired composition, quantity of different dairy and non-dairy ingredients is calculated. There are various methods followed for calculating amount of ingredients viz.

- Algebraic method
- Pearson square method
- Serum point method
- Computer developed formulations
- Formula tables/graphics method

These methods are used based on the type of mix and the time required for calculations.

Blending of mix

Blending of all the ingredients is done in vat which is equipped with agitators and has provision for heating. All the liquid ingredients are first placed in the vat and agitation and heating is started. The dry ingredients like skim milk powder, stabilizer, sugar etc. are added to the vat before the temperature reaches 50°C. The temperature of adding dry ingredients also depends on the type of ingredients particularly stabilizer.

Pasteurization of mix

Pasteurization is done to destroy all the pathogenic bacteria in the mix so as to render the final product safe for human consumption. In addition to this very important function, pasteurization also reduces the number of spoilage organisms such as psychrotrophs, and helps to hydrate some of the components (proteins, stabilizers). Both batch (69°C/30 min) and continuous (80°C/25 sec or 135-149°C for few sec) methods are used for mix pasteurization.

Advantages of pasteurization are:

- it renders the mix entirely free of pathogenic bacteria
- it helps in blending the ingredients of the mix

• it improves flavour
• it improves keeping quality
• it produces a more uniform product

Homogenization of mix

Homogenization is an important step in cream for making permanent emulsion of fat. Two-stage homogenization is usually preferred for ice cream mix. Clumping or clustering of the fat is reduced thereby producing a thinner, more rapidly whipped mix. Melt-down properties of ice cream is also improved. Other than reducing fat globules size and forming emulsion, homogenization have some indirect advantages like it makes a smoother ice cream, results in better air stability and also increases resistance to melting.

Homogenization of the mix should take place at the pasteurizing temperature. The high temperature produces more efficient breaking up of the fat globules at any given pressure and also reduces fat clumping and the tendency to thick, heavy bodied mixes. If a two stage homogenizer is used, a pressure of 2000 - 2500 psi on the first stage and 500 - 1000 psi on the second stage should be satisfactory under most conditions.

Cooling the mix

Mix should be cooled immediately after homogenization to 0-5°C and held at the same temperature until used. Slow cooling of the mix increases viscosity and also results in ice cream that does not melt smoothly. Cooling to such a low temperature also retards growth of bacteria.

Ageing the mix

The mix is then aged for at least four hours and usually overnight. Two important processes take place during ageing (Fig. 10). First, the emulsifiers adsorb to the surface of the fat droplets, replacing some of the milk protein. Second, the fat inside the droplets begins to crystallize. Without these two processes, it is difficult to incorporate and stabilize air bubbles when the mix is frozen in the freezer. The ageing time, hence the extent of fat crystallization and emulsifier adsorption, depends on the nature of the mix. Overnight ageing is usually sufficient for all types of mixes.

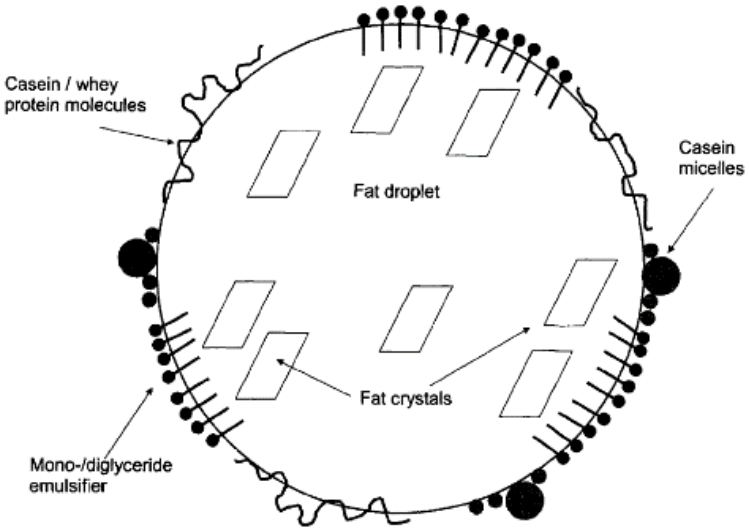


Fig. 10: Adsorption of milk proteins and emulsifiers at the surface of the fat droplet and crystallization of the fat (Source: Vivek, 2001)

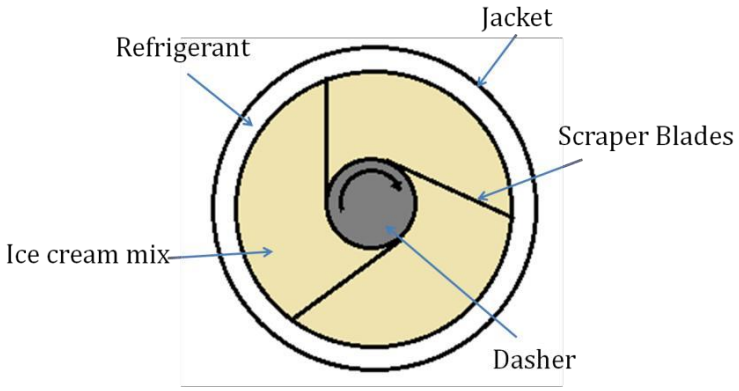


Fig. 11. Ice Cream Freezer Illustration

Freezing

Ice cream mix after cooling and ageing is frozen in ice cream freezers. These freezers can be of batch type or continuous. The ice-cream freezer converts mix into ice cream by simultaneously aerating, freezing and beating it, to generate the ice crystals, the air bubbles and the matrix. 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 ice cream is drawn off within 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. Air is also

incorporated to obtain the required over-run in the semi frozen mass during freezing process. This is achieved by supplying compressed air into the freezer.

As the ice cream is drawn from the freezers, particulate matter such as fruits, nuts, candy, cookies, etc. 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.

Hardening

When ice cream is drawn from freezer, its consistency is such that it can be filled in containers like cups or in bulk packages. After filling into packs, it is necessary to lower the temperature of ice cream as quickly as possible. This is known as hardening. Hardening of ice cream is essential to stabilize the microstructure of the product after freezing and air incorporation.

Ice cream is hardened in a hardening tunnel, an enclosed chamber into which the ice cream passes on a conveyor belt from the freezer. Inside, cold air (typically - 30 °C to - 45 °C) is blown over the ice cream. The lower the air temperature and the faster the air flow, the faster heat is removed from the ice cream. Cold stores, which are typically about -25 °C, are not suitable for hardening because they are not cold enough and have still air, so they cannot cool the ice cream rapidly enough to minimize recrystallization. Hardened ice cream is then stored at temperature -23°C to -18°C so as to keep the structure stable.

Storage

The ice cream should be stored in a deep freezer at -18 to -23°C. It should not be allowed to melt for two reasons: first this would allow any bacteria in the ice cream to grow and spoil the product, and secondly the air in the ice cream escapes and it loses its texture to become solid ice when re-frozen. When the molten ice cream re-freezes, ice crystals formed are much larger than the crystals formed in freezers and the ice cream taste more ‘gritty’.

Other frozen dairy products

Other frozen dairy products are soft serve ice cream, Kulfi, milk ices etc. All these products differ slightly in composition and method of manufacturing but the basic process remains similar to ice

cream. Soft serve ice cream is much similar to ice cream with the differences that it is not hardened and it has less overrun than ice cream. Kulfi is a product made from mix which may or may not have higher total solids than ice cream but the concentration is achieved by severe heating of mix made of milk/ cream/ SMP, sugar, nuts etc. This mix is frozen with almost no overrun which provides kulfi its characteristic body and texture.

Condensed and Dried Milks

Evaporated milk means the product obtained by partial removal of water from milk by heat or any other process which leads to a product of the same composition and characteristics. The raw materials for evaporated milk consists of milk and milk powders, cream and cream powders and milk fat products. Potable water and sodium chloride are also permitted in manufacturing process of evaporated milk. Dried milk products containing less than 4% water are obtained by removal of water from milk using any method/equipment of drying such as drum dryer, spray drier and freeze drier, whilst concentrated milk products are obtained by partial removal of water using evaporator, reverse osmosis, and vacuum tray driers. Drying and concentration reduces volume and weight, thereby reducing transportation cost. Numerous milk product can be converted into dried form using some technical interventions. Majorly dried milk products include skim milk powder (SMP), whole milk powder (WMP), whey powder, cream powder etc. which possess longer shelf-life, owing to inhibition of microorganisms due to low water activity (<0.1).

Table. Legal Requirements of evaporated milks as per FSSR, 2017

Parameter	**Evaporated milk**	**Evaporated partly skimmed milk**	**Evaporated skimmed milk**	**Evaporated high fat milk**
Milk fat, %, (m/m)	7.5 (minimum)	More than 1 and Less than 7.5	1.0 (maximum)	15.0 (minimum)
Milk solids, minimum, %, (m/m)	25.0	20.0	20.0	26.5
Milk protein* in milk solids-not fat, minimum, %, (m/m)	34.0	34.0	34.0	34.0
"Evaporated partly skimmed milk" may be designated "evaporated semi-skimmed milk" when the content of milk fat is between 4.0 - 4.5 % (m/m) and minimum milk solids is 24% (m/m).				

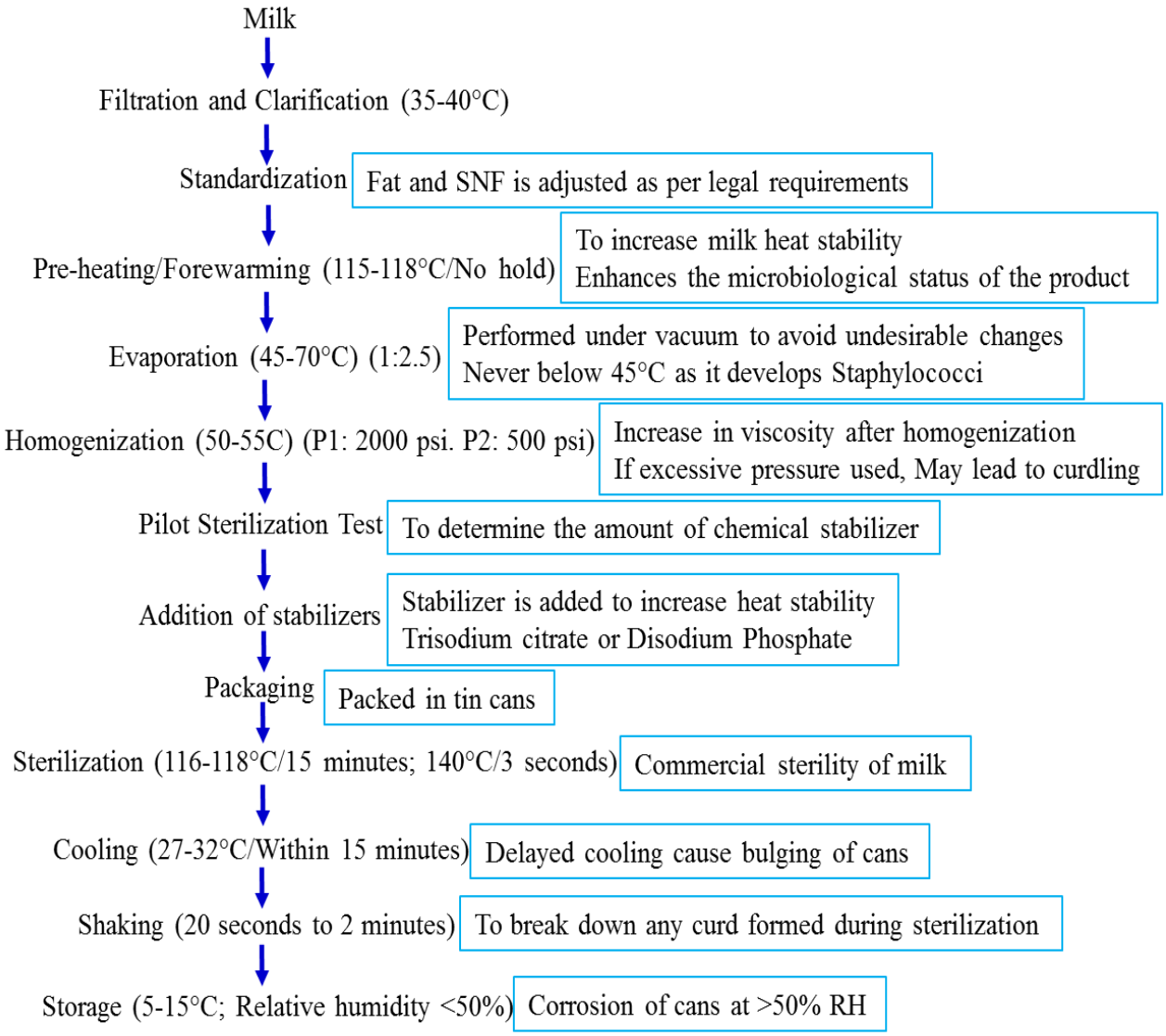


Fig.12. Flow diagram for evaporated milk production

Sweetened Condensed Milk is the product obtained by partial removal of water from milk with the addition of sugar or a combination of sucrose with other sugars, or by any other process which leads to a product of the same composition and characteristics. The fat or protein content or both of the milk may be adjusted, only to comply with the legal compositional requirements, by addition or withdrawal of milk constituents in such a way as not to alter the whey protein to casein ratio of the milk being adjusted. The raw materials and permitted ingredients for sweetened condensed milk consists of potable water, milk and milk powders, cream and cream powders, milk fat

products, sucrose, sodium chloride and lactose for seeding purposes. Milk retentate, the product obtained by concentrating milk protein by processes like ultrafiltration of milk, partly skimmed milk, or skimmed milk, could be used for protein adjustment purpose.

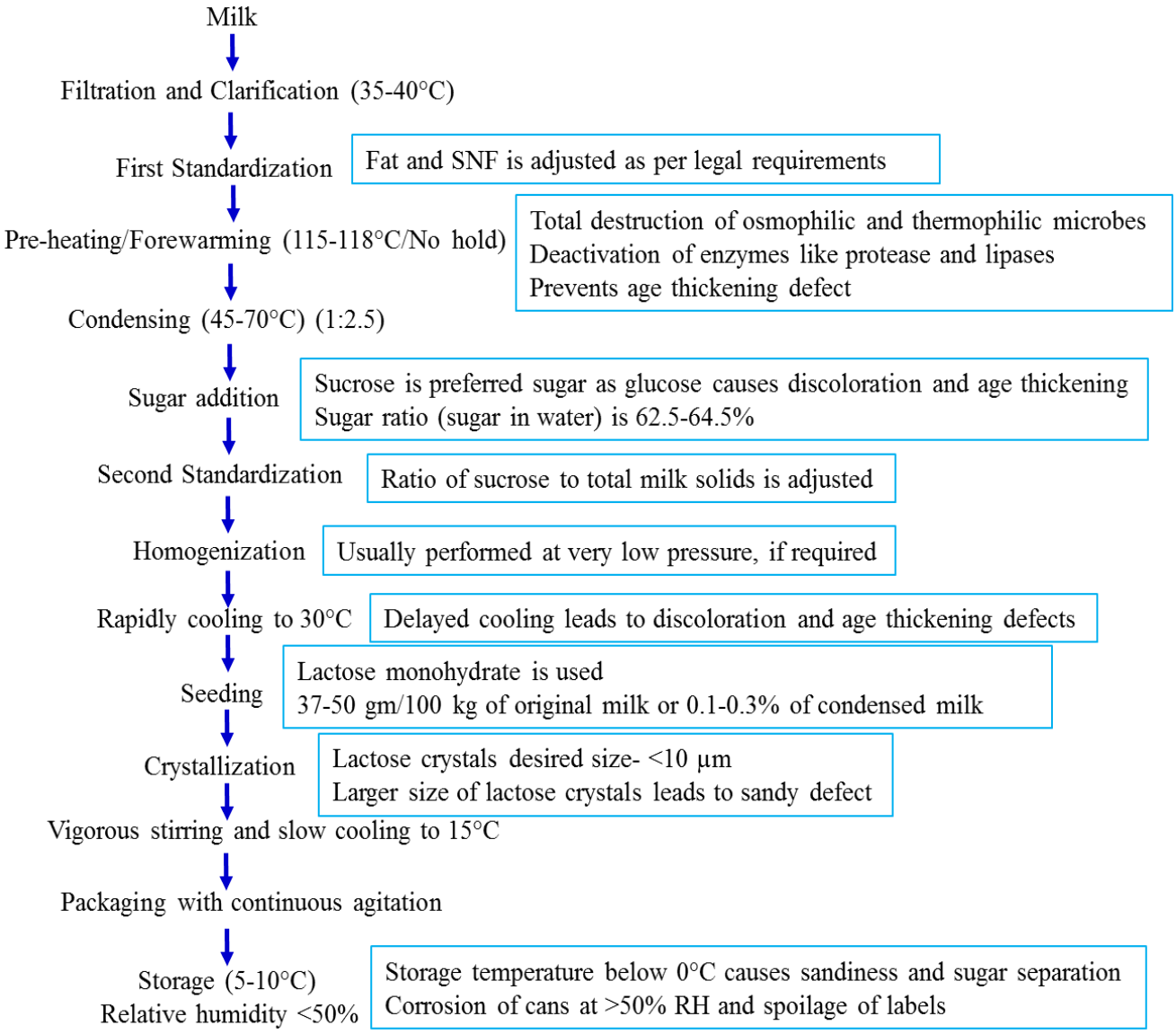


Fig. 13. Flow diagram for condensed milk production

Milk powders and cream powder are milk products which are obtained by partial removal of water from milk or cream. The fat or protein content, or both of the milk or cream may be adjusted, only to comply with the compositional requirements mentioned in tabular form, by addition or

withdrawal of milk constituents in such a way as not to alter the whey protein to casein ratio of the milk or cream being adjusted. The product shall be free from added whey and whey preparations.

Table. Legal Requirements of condensed milks as per FSSR, 2017				
Parameter	**Sweetened condensed milk**	**Sweetened condensed partly skimmed milk**	**Sweetened condensed skimmed milk**	**Sweetened condensed high fat milk**
Milk fat, %, (m/m)	8.0 (minimum)	More than 1.0 and less than 8.0	1.0 (maximum)	16.0 (minimum)
Milk solids, minimum, %, (m/m)	28.0	24.0	24.0	--
Milk solid not fat, minimum, %, (m/m)	--	20.0	--	14.0
Milk protein* in milk solids-not-fat, minimum, %, (m/m)	34.0	34.0	34.0	34.0

Table. Legal Requirements of dried milks as per FSSR, 2017				
Parameter	**Whole Milk Powder**	**Partly Skimmed Milk Powder**	**Skimmed Milk Powder**	**Cream Powder**
Moisture*, maximum, %, (m/m)	5.0	5.0	5.0	5.0
Milk fat, %, (m/m)	Minimum 26.0 and less than 42.0	More than 1.5 and less than 26.0	1.5 (maximum)	42.0 (minimum)
Milk protein in milk solids-not-fat, minimum, %, (m/m)	34.0	34.0	34.0	34.0
Titrable acidity, maximum (ml 0.1 NaOH for 10 g - solids-not-fat)	18.0	18.0	18.0	--
Insolubility Index, maximum, ml	2.0	2.0	2.0	--
Total ash, maximum, % (m/m), on moisture and fat free basis	9.3	9.3	9.3	--
Scorched particles, maximum	Disc B	Disc B	Disc B	Disc B

Roller drying or drum drying or film drying is based on contact of pre-concentrated milk on roller surface heated by steam. Water evaporates and a thin layer of dried milk is formed on the roller which is scraped off by scraper blades. Finally, the product is pulverized or sifted in hammer mill

or sifter. Roller dried powder particles are of 8-20 µm size with irregular shapes. The powder particles have slightly darker color. Spray drying method is most predominantly used method in dairy industry where concentrated milk is exposed to hot air in drying chamber. Pre-concentrated milk is atomized in small milk droplets using centrifugal, nozzles or pneumatic atomizers. Spray dried powder particles are having smooth surface and 10-250 µm size. The powder particles carried away by air are recovered in cyclone separators, bag filters or wet scrubbers. Milk powders can be made easily/readily soluble by using agglomeration process. Agglomeration involves the incorporation of air between powder particles which is replaced by water during reconstitution.

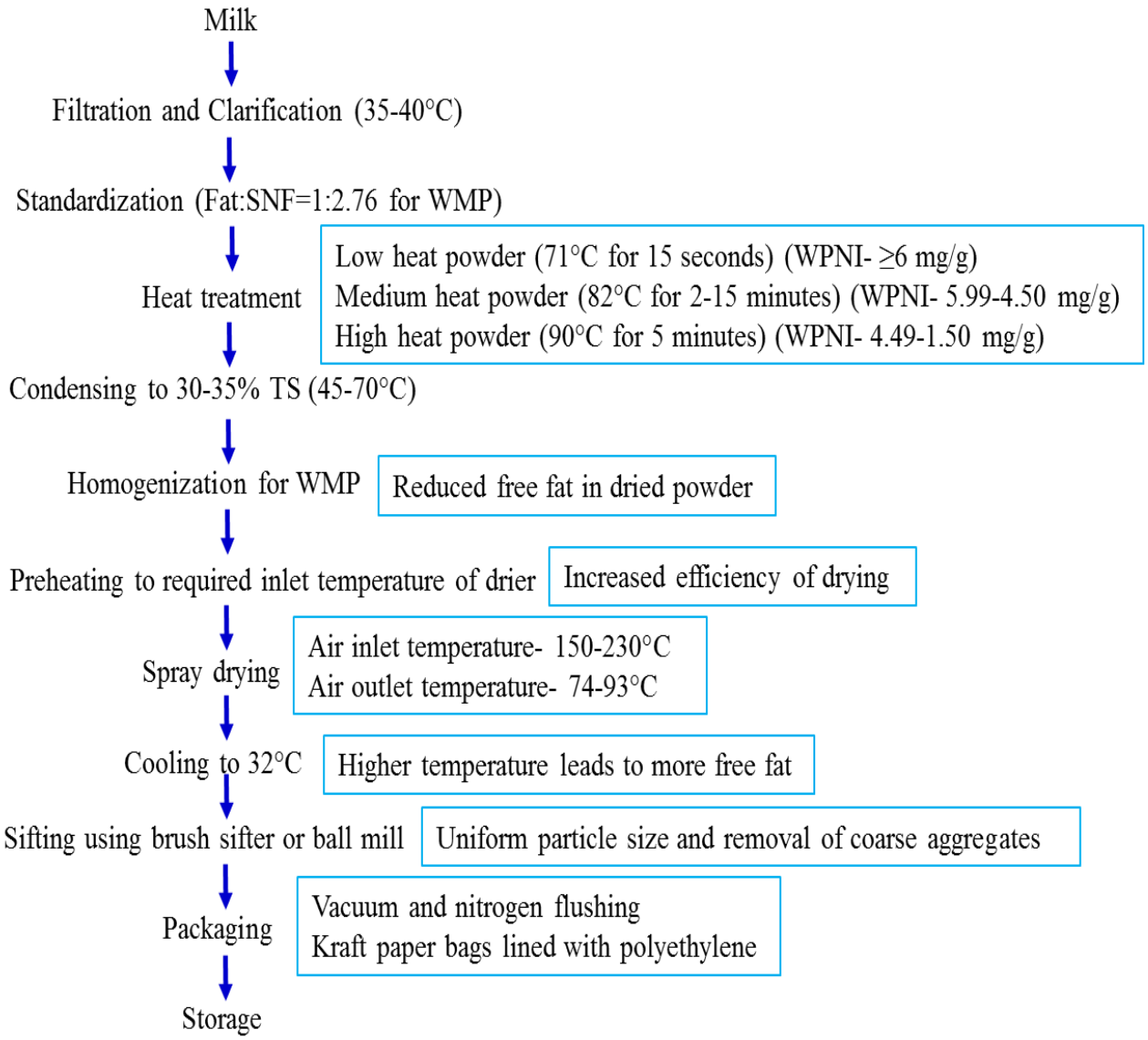


Fig. 14 Generalized flow diagram for milk powder production

Whey is the fluid milk product obtained during the manufacture of cheese, casein or similar products by separation from the curd after coagulation of milk or of products obtained from milk, or both. Coagulation is obtained through the action of, principally, suitable enzymes of non-animal origin. Acid whey is the fluid milk product obtained during the manufacture of cheese, casein, *paneer, channa* or similar products by separation from the curd after coagulation of milk and of products obtained from milk. Coagulation is obtained, principally, by acidification and heating. Whey powders are milk products obtained by drying Whey or Acid Whey. Seed lactose in the manufacture of pre-crystallized Whey Powder.

Table. Legal Requirements of whey powders as per FSSR, 2017		
Parameter	**Whey Powder**	**Acid Whey Powder**
Moisture, maximum, %, (m/m)	5.0	4.5
Milk fat, maximum, %, (m/m)	2.0	2.0
Milk protein, minimum, %, (m/m)	10.0	7.0
Lactose content, as anhydrous lactose, minimum, %, (m/m)	61.0	61.0
pH (in 10% solution)	More than 5.1	5.1(maximum)
Total ash, maximum, %, (m/m) (on dry basis)	9.5	15.0

Table. Additives permitted in condensed milk (plain), evaporated milk(s), sweetened condensed milk(s)		
Food Additive	**INS No.**	**Recommended Maximum Level**
Calcium carbonate	170	2,000 mg/kg singly or 3,000 mg/kg in combination (Total salt content shall not exceed 3,000 mg/kg calculated as phosphorus/ carbonates /citrate/ chloride)
Sodium citrates	331	
Potassium citrates	332	
Calcium citrates	333	
PHOSPHATES		
Sodium carbonate	500	
Potassium carbonate	501	
Potassium chloride	508	
Calcium chloride	509	
Glucono delta lactone	575	GMP
Propionic acid; sodium and calcium propionate expressed as propionic acid (singly or in combination)	280, 281, 282	2,000 mg/kg
Sorbates		2,000 mg/kg
Nisin	234	12.5 mg/kg
Carrageenan	407	150 mg/kg

*****

Technology of *Khoa, Chhana* and *Paneer*

Kaushik Khamrui

Principal Scientist, Dairy Technology Division, iCAR-National Dairy Research Institute, Karnal

INTRODUCTION

Khoa also unknown as Khoya, Mawa, Khava, Palghoa occupies a place of prominence among traditional Indian milk products. According to a rough estimate about 6.5-7.0% of the total milk produced in India is converted into khoa. There is practically no reduction in the milk utilize for khoa making during the last 20 years in spite of the concentrated attempts of the dairy development authority to discourage such utilization. It is evident therefore, that the indigenous products cannot be over taken by other western dairy products. Khoa is a heat coagulated milk product prepared by partial dehydration of cow, buffalo or mixed whole milk and does not contain any ingredient foreign to milk. It is used as a base material in the preparation of a variety popular meats sweet viz., burfi, peda, gulabjamun, kalakand, milk cake etc. Buffalo milk is usually preferred for the manufacture of khoa since it produces khoa with desirable body and textual qualities and gives higher yield. The higher emulsifying capacity of buffalo milk fat due to the presence of higher proportions (50% than only 35% in cow milk fat) of butyric acid containing triglycerides and higher fat content in buffalo milk is responsible for smooth and mellow texture of buffalo milk khoa.

Paneer and *chhana* are heat and acid coagulated milk products obtained when standardized milk was coagulated with the permitted acids at specified temperature, resultant coagulum is filtered and pressed to get the solid curd mass. *Paneer* has firm, close, cohesive and spongy body and smooth texture. *Paneer* is mainly prepared from buffalo milk and used for manufacture of a variety of culinary dishes. Though originally it was localized in North Western part of India but now it has traveled almost all parts of the country. *Paneer* is generally sold as blocks or slices, it also refer as Indian fresh cheese.

Chhana looks off-white, tastes mildly acidic, and has characteristic spongy texture. Production of *chhana* is confined to mostly in Eastern region of the country notably West Bengal, Bihar and Orissa. Cow milk is generally preferred for *chhana* making as it gives soft and smooth *chhana* which is suitable for sweets preparation. Buffalo milk, on the other hand because of its inherent

chemical properties (high levels of calcium etc.) results in hard and grainy *chhana*. A variety of sweets like *sandesh, rasogolla, cham-cham, rasmalai, pantooa, chhana murki* etc. are prepared from *chhana*. Depending on the end use, *chhana* may be of a soft or hard variety. Rasogolla requires soft *chhana* while sandesh requires hard variety.

KHOA

FSSR (2011) Definition of khoa (As amended in 2018)

Khoa by whatever name it is sold such as Khoa or Mawa or any other region specific popular name means the product obtained by partial removal of water from any variant of milk with or without added milk solids by heating under controlled conditions.

Essential Composition and Quality Factors. -

(a) Raw materials. - Milk and milk powders, cream and cream powder and milk fat products.

(b) Composition - The product shall conform to the compositional specifications provided in the table below:

Parameters	Requirements
Total solids, minimum, %, (m/m)	55.0
Milk fat, minimum, %, (m/m), dry matter basis	30.0
Total ash, maximum, %, (m/m)	6.0
Titratable acidity (as % lactic acid), maximum, %	0.9

It shall be free from added starch and added sugar. The extracted fat from Khoa shall meet the standards for Reichert Meissl value, Polenske value and Butyro-refractometer reading as prescribed for ghee.

Classification of Khoa: There are three major types of khoa, viz., pindi, danedar and dhap. The characteristics of each variety of khoa are as follows:

Pindi: It is characterized as a circular ball of a hemispherical pat with smooth homogeneous body and texture. The product should be free from burnt particles as well as any browning defects. It should have characteristic cooked flavour and free from objectionable odour and sour (acidic) taste.

Danedar: It is characterized by its granular texture and uneven body. The size of grains depends upon amount of coagulant added usually citric acids and the quantity of milk used. This type of khoa is used as a base for the preparation of kalakand, cakes and pastries where granulation is valued to a great extent.

Dhap: It is characterized by loose and sticky body and smooth texture. It contains higher moisture content than pindi and danedar variety. It is preferred for the preparation of gulabjamun as it forms uniform balls with desired rheological characters ties after frying and soaking in sugar syrup. The quality difference in the khoa prepared influences the price of the product. Three types of khoa viz., pindi, dhap and danedar are sold in the market at different prices. Quality within the same type is a function of production techniques. Pindi sells at a higher price followed by dhap and danedar. Each of these varieties is in demand and is required for specific type of sweets. The physico-chemical characteristic of various types of khoa is presented in Table 1.

Table 1. Physico-chemical characteristics of khoa varieties

	Pindi	**Dhap**	**Danedar**
Moisture %	31-32	37-44	35-40
Fat %	21-26	20-23	20-25
Lactic Acid	0.34	0.30	0.36
Body and Texture	Firm, Smooth	Loose, Sticky	Grainy
Keeping quality at 30℃ (in days)	6	3	3
Uses	Burfi (plain, pista, chocolate, coconut) Peda etc.	Gulabjamun, Pantooa, Toffees, Coconut balls, etc.	Kalakand, Cake, Doda burfi, etc.

BIS Standard for *khoa*: According to BIS, only fresh, clean milk, free from colostrums and in every way fit for human consumption shall be used. The milk shall be free from adulterants, preservatives and any matter foreign to milk. The final products must conform to the requirements given in Table 2.

Method of production

Traditional Method: Milk in small lots (not more than 5-7 litres) per batch is taken in an open pan, 1/4 to 1/5 of the total capacity and boiled over brisk non-smoky fire. The milk is stirred vigorously and constantly with a circular motion by a ladle. During this operation all parts of the

pan with which milk comes into contact are lightly scraped to prevent the burning of milk solids on the surface of the pan. Constant evaporation of moisture takes place and the milk thickens progressively. At a certain concentration (for cow milk ~2.8 and for buffalo milk~2.5) heat coagulation of milk proteins begin and the concentrates becomes progressively insoluble in water. This stage is marked by a sudden change in colour. The heating is continued with greater control here in after and the speed of stirring and scrapping is increased. Soon the viscous mass reaches a semi solid/pasty consistency and begins to dry up. Very close attention is paid to the last stage. The final product is ready when it shows signs of leaving the bottom and the sides of the pan and sticking together. At this stage the pan is preferably removed from the fire and khoa is spread to the side of pan and allowed to cool slowly before forming into a pat. The finished product is transferred to the aluminum containers of generally of 1 kg size. The operation of khoa is completed in about 15-20 minutes.

However, there are several limitations of this method, such as:

1) Time and labour consuming
2) Large variation in quality
3) Poor keeping quality
4) Small scale production
5) Smoky smell

Table 2. BIS Requirements for Khoa

Characteristic	**Requirement**		
	Pindi	***Danedar***	***Dhap***
(i) Total solids percent by mass, Minimum	65	60	55
(ii) Fat, percent by mass (on dry basis), Minimum	37	37	37
(iii) Total ash, percent by mass (on dry basis), Maximum	6.0	6.0	6.0
(iv) Titratable acidity, (as lactic acid) per cent by mass basis, Maximum	0.8	0.9	0.6
(v) Coliform count per gram, Maximum	90	90	90
(vi) Yeast and Mould count per gram, Maximum	50	50	50

Improved Method: It makes use of improved equipment such as a stainless steel made double jacketed kettle with steam supply which is used for boiling milk. It has provision of controlling the heating by regulating steam values. The amount of heat handled per batch is 1/4 to 1/5th of the

total capacity of pan used. For 20 litres of batch milk, it takes about 20 minutes for conversation into khoa.

Mechanization of khoa manufacrure

The most successful and presently being installed and used at a few commercial dairy factories are:

I) Inclined Scrapped Surface Heat Exchanger (ISSHE) developed by National Dairy Development Board (NDDB), Anand in 1990 and

II) Thin-film Scrapped Surface Heat Exchange (TSSHE) developed by National Dairy Research Institute, Karnal in 1992.

I) Inclined Scraped Surface Heat Exchanger (ISSHE): The unit comprises of a balance tank, a positive displacement pump and an inclined scraped surface heat exchanger (ISSHE).The feed tank is made of stainless steel and has a capacity of 50 litres. A variable capacity feed pump is used to feed concentrated milk to the ISSHE at the desired flow rate of 60-80 lts/hr. The angle of inclination for the inclined scraped surface heat exchanger could be varied from 0 to 30°. The heat exchanger comprises of inner cylinder, rotor, drive and outer steam jacket. The inner cylinder is of stainless steel and forms the main body. The inner shell is provided with steam jacket which is split into three separate compartments. The steam jacket is insulated and cladded. The design of rotor is the key factor in this innovation. It combines the functions of scraping and conveying. The rotor is driven by a variable speed drive and speed could be varied between 40-80 rpm. A schematic diagram of the ISSHE for khoa making is shown in Fig 1.

Operation of the equipment:

Milk concentrate (40-45% TS of 50℃) as a feed is pumped in the inlet of the ISSHE at the desired flow rate by adjusting the capacity of the feed pump. At the start of the operation the inclination of ISSHE permits formation of a pool of boiling milk is critical to the development of desired flavour in khoa. Subsequently, fresh concentrated feed enters this pool of boiling concentrated milk, while an equivalent mass continuously leaves the pool as semi-solid mass. The scraper repeats the process of removing coagulated particles from the heat transfer surface and mixing them back into the pool of heated milk. The coagulated particles absorb milk resulting in the agglomeration and formation of characteristics khoa texture. The inclination of the scraper

provides interface between metal, milk and air which enhances the heat coagulation of proteins. The process of khoa making as it takes place in the open pan employing conventional method that is replicated in the ISSHE. The wet coagulated particles are pushed ahead by the screw conveyer. By varying the inclination, flow rate, pressure in heating jacket, scraper/screw speed and total solids and temperature of the feed, the capacity, residence time as well as the product characteristics can be varied. At the end of the process run the concentrate milk is stopped by diverting of water supply.

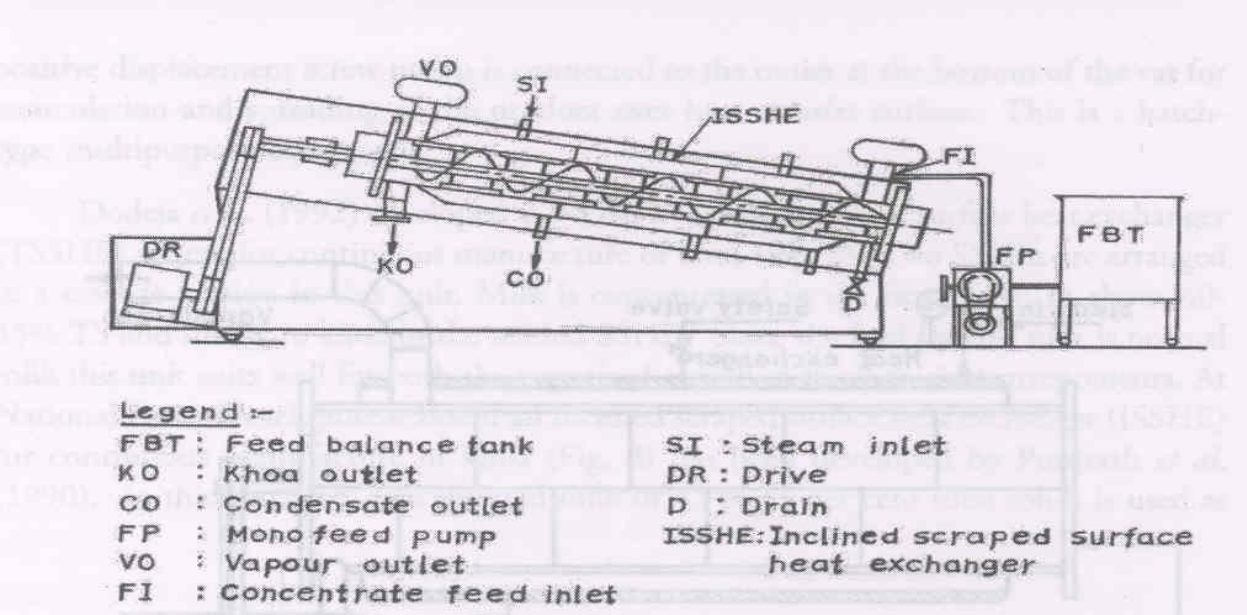


Fig.1. Inclined Scraped Surface Heat-Exchanger for Continuous Khoa Making

II) Thin Film Scraped Surface Heat Exchanger (TSSHE):

The continuous khoa making system developed by NDRI is also based on the principle of scraped surface heat exchanger (SSHE). In this, two SSHEs are arranged in cascade fashion. The rotor of the first SSHE is provided with variable clearance blades and operates at 3.3 rps (200 rpm). Whole milk is concentrated in this SSHE in the range of 40-45% TS. The concentrated milk then enters into the second SSHE which has a different kind of rotor arrangement. It has two variable clearance blades and two helical blades which operate at a speed (140-150 rpm). Both the SSHE are double jacketed and filled with steam supply line, pressure gauge and vapours outlet. Contrary to the ISSHE, the cylinder in this unit are placed horizontally, one after the other. The milk is fed into

the first SSHE with a centrifugal pump whereas the concentrated milk from 1st SSHE to 2nd SSHE goes by gravity. It can produce about 40 kg khoa/hr.

CHHANA AND *PANEER*

FSSR (2011) Definition of *Chhana* and *Paneer* (As amended in 2018)

Chhana or *Paneer* means the product obtained from any variant of milk, with or without added milk solids, by precipitation with permitted acidulants and heating.

Essential Composition and Quality Factors.-

(a) Raw materials - (i) Milk (ii) Milk solids

(b) Permitted ingredients –

(i) Acidulants such as lactic acid, citric acid, malic acid, vinegar, glucono delta lactone, sour whey;

(ii) spices and condiments (for flavoured *paneer* only);

(iii) salt (for flavoured *paneer* only).

(c) Composition. –

The product shall conform to the compositional specifications provided in the Table-3

Table-3 Parameter *Chhana* or *Paneer* Low fat *Chhana* or *Paneer*

Parameters	***Chhana* and *Paneer***	**Low fat *Chhana* and *Paneer***
Moisture, maximum, %, (m/m)	65.0 (for *Chhana*) 60.0 (for *Paneer*)	65.0 (for *Chhana*) 60.0 (for *Paneer*)
Milk fat, %, (m/m), dry matter basis	50.0 (minimum)	15.0(maximum)

According to FSSAI (2011), *paneer* or *chhana* means the product obtained from the cow or buffalo milk or a combination thereof by precipitation with sour milk, lactic acid, or citric acid. It shall not contain more than 70% moisture and milk fat content shall not be less than 50% of the dry matter. Milk solids may also be used in the preparation of these products. *Paneer* or *chhana* when sold as low fat product, they shall conform to the following requirements: (i) Moisture Not more than 70.0 percent; (ii) Milk fat Not more than 15.0 percent of dry matter: Provided further that such low fat *paneer* or *chhana* shall be sold in sealed package only and shall bear proper label declaration as provided in regulation i.e. low-fat *paneer* or low-fat *chhana*.

Methods of *paneer* manufacturing

Traditional method of manufacture

Buffalo milk is boiled in a suitable iron vessel and a small portion of this is then transferred to a smaller vessel. The coagulant (usually sour whey) is added to the hot milk and stirred with a ladle till coagulation is completed. The contents of the vessel are emptied over a piece of coarse cloth to drain off whey. The whole process is repeated till all the milk is converted into *paneer*. The curd is collected after draining the whey and pressed to remove more whey. Finally, product is then washed with cold tap water.

Industrial method for paneer manufacturing

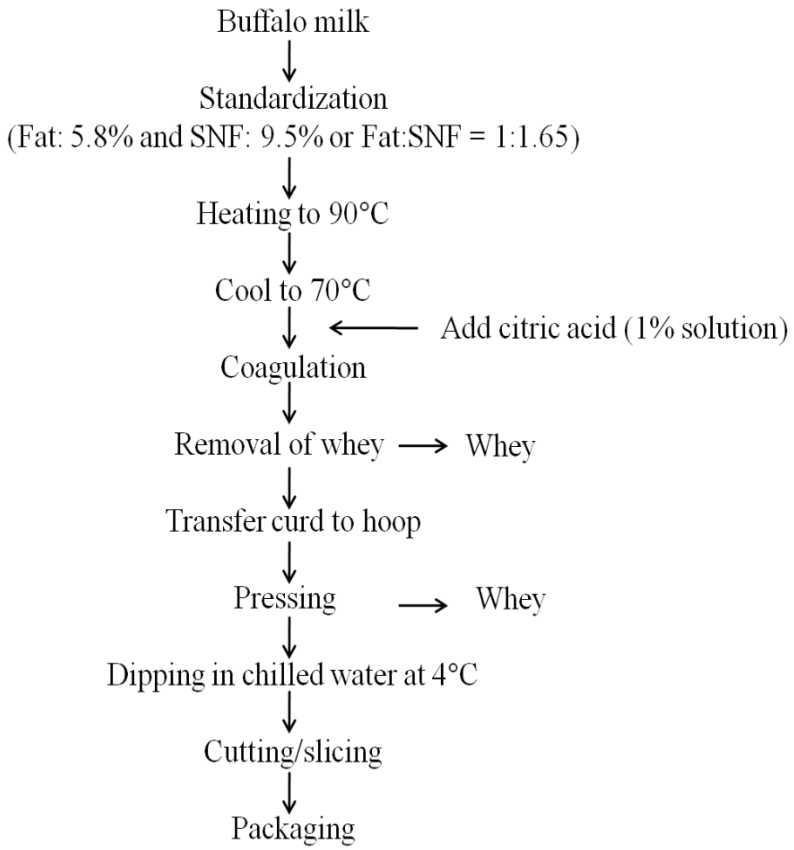


Fig. 2. Flow diagram for the industrial manufacture of *paneer*

Buffalo milk is standardized to 5.8% fat having 9.5% SNF (fat: SNF ratio of 1:1.65). Standardized buffalo milk is heated to 90°C without holding (or 82°C with 5 minutes holding) in a jacketed vat and cooled down to 70°C. Coagulation is done at about 70°C by slowly adding 1% hot (70°C) citric acid solution with constant stirring till a clean whey is separated at (pH 5.30 to 5.35) and

coagulum is allowed to settle for 5 minutes then whey is drained off. The curd so obtained is filled into hoops lined with cloth. Pressure is applied on top of the hoop at a rate of 0.5 to 1.0 kg/cm^2. The pressed blocks of *paneer* are removed from the hoops and immersed in chilled water for 2-3 h. The chilled *paneer* is then removed from water to drain out. Finally, *paneer* blocks are wrapped in parchment paper / polyethylene bags and placed in cold room at about 5 to 10°C.

***Paneer* form cow milk**

Cow milk yields an inferior product in terms of body and texture. It is criticized to be too soft, weak and fragile and unsuitable for frying and cooling. Buffalo milk contains considerably higher level of casein and minerals particularly calcium and phosphorous, which tends to produce hard and rubbery body while cow milk produces soft and mellow characteristics. By replacing one third of buffalo milk with cow milk a good quality *paneer* can be made. Buffalo milk *paneer* retains higher fat, protein and ash content and lactose as compared to cow milk *paneer*. To make *paneer* exclusively from cow milk, certain modifications in the conventional procedure have to be made. Addition of calcium chloride at the rate of 0.08 to 0.1% to milk helps in getting a compact sliceable, firm and cohesive body and closely knit texture. A higher temperature of coagulation (85-90°C) with optimum pH of coagulation of 5.20 to 5.25 keeps in producing good quality *paneer* from cow milk. However, at this pH of coagulation, moisture, yield and solids recovery are less.

Recent Developments in Paneer Manufacturing

a) Use of Ultrafiltration in paneer manufacturing: Ultrafiltration (UF) can be used for the manufacture of *paneer* which offer advantages like access to mechanization, uniform quality, improved shelf-life, increased yield and nutritionally better product. In this process, milk after standardization and heating is passed through UF membrane where lactose, water and some minerals are removed as permeate. The concentrated mass which has about 40% total solids is cold acidified to get the desired pH. Up to this point the product is flowable and can be easily dispersed into containers with automatic dispersing machines. The filled containers can then be subjected to texturization by passing through microwave tunnels. The resulting product has typical characteristics of normal *paneer*. The yields increase by about 25% which is due to the retention of good quality whey proteins and slightly increase in moisture content (moisture about 70%) yield is about 25%.

b) In-package long life paneer like product: A fully mechanized process has been developed which yields a long shelf life *paneer* like product. In this process standardized buffalo milk is concentrated partly by vacuum concentration process and partly by UF to a total solids content of 30% and then acidified using Glucono-Delta-Lactone (GDL). After packaging in metallized polyester pouches, the product is formed by texturizing process at 115°C for 5 min which permits concomitant sterilization. The yield of *paneer* is more due to retention of whey solids and the shelf-life is 110, 80 and 47 days at 25, 35 and 45°C, respectively.

c) Continuous manufacture of paneer: A continuous *paneer*-making system was developed at NDRI, Karnal by Agrawala et al. (2001). In this system, the unit operations involved in *paneer* making have been mechanized. The continuous *paneer* making machine is designed to manufacture 80 kg *paneer* per hour by employing twin-flanged apron conveyor cum filtering system for obtaining the desired moisture content and texture attributes.

Methods of *chhana* manufacturing

Traditional method of manufacture

Chhana is prepared by boiling about 20-40 L of cow milk or mixed milk in an iron Karahi on a coal or fire wood chullah. Cooled at 80-85°C and coagulated in small installments (of 5-10 L at a time) with citric/ tartaric or sour whey while gently stirring the contents with the help of a laddle till clear whey is obtained. Curd is allowed to settle for 1-2 minutes and whey is drained through muslin cloth. Normally pressing of curd is restricted to control the moisture content which is obtained by gravity. Conventional method of *chhana* making is cumbersome, time-consuming, labour intensive, difficult to attain high quality standards and results in uneven product quality. SS vats and plate heat exchanger or steam jacketed kettle have been used for heating of milk and for storage of liquid milk at industrial production. Other process controls like temperatures of heating of milk, coagulation and coagulant are very precisely maintained as shown in Fig 3. Also, SS strainers with cloth lining are used to filter the whey out of coagulum.

Mechanized system for chhana making

A prototype machine with a capacity to produce 40 kg of *chhana*/ hour has been developed by (Aneja *et al.,* 1982). The equipment consists of a balance tank, injection chamber, holding coil, cooling chamber and a strainer. The standardized cow milk is pumped from the balance tank @ of

250 L of milk/h to an injection chamber where culinary live steam (at 1 kg/cm^2 pressure and at the rate of 65kg/h) is directly injected into the milk. The steam gets completely condensed in milk and the temperature is raised to 90-95°C. Thereafter the milk is brought in contact with sour whey, the quantity of which is regulated in proportion to the rate of milk flow. The mixture of whey and milk is circulated through a holding coil (8m x 10mm) to facilitate complete coagulation of milk. The coagulated product along with whey is then pumped into a double jacketed cooling tank, where it is cooled down to room temperature. Finally the product is taken to mechanical strainer, a double jacketed mechanical strainer, a double jacketed inclined sieve, where it is drained thoroughly. *Chhana* with 55-65% moisture is discharged through the outlet and collected in the container. Drained whey is transferred to a holding tank for souring for subsequent use.

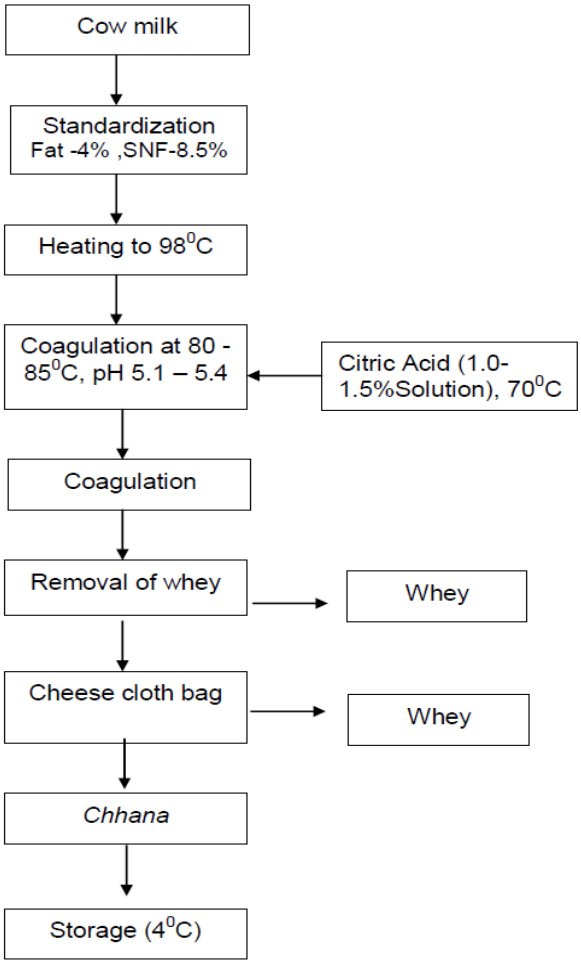


Fig. 3. Industrial production of *chhana* from cow milk

Recently, workers at Indian Institute of Technology, Kharagpur developed a continuous *chhana*-making unit of 60 L/h of milk capacity (Sahu and Das, 2007). The unit has a duplex plunger pump for dosing of milk and acid. Helical coil heat exchanger was used to heat the milk prior to acid coagulation. It also consists of a vertical column that gives residence time for the separation of milk solids to *chhana*.

Preparation of *chhana* from buffalo milk

In India about 53% of the total milk produced is from buffaloes which is about 90% of the total milk handled by the organize sector. Dairy plants prefer to buy buffalo milk as it contains higher proportion of fat and total solids than cow milk. Because of many inherent differences in physico-chemical makeup of cow and buffalo milk, several problems are encountered during processing of buffalo milk. Calcium content has direct correlation with hardness of *chhana* prepared from buffalo milk. The high calcium and casein (cow milk 2.42 to 2.7% casein and buffalo milk 2.6 to 3.38% casein) content in buffalo milk tender it unfit for preparation of most *chhana* based sweets. Few attempts have been made to produce *chhana* from buffalo milk.

a) ***Admixture with cow milk:*** Buffalo milk (up to 25%) in combination with cow milk (75 parts of cow milk and 25 parts of buffalo milk) gives acceptable quality *chhana*.

b) ***Addition of Stabilizer:*** Addition of mixture of 75 g sodium dihydrogen phosphate and 58 g of disodium hydrogen phosphate per 100 L of buffalo milk produces good quality *chhana*. Guar gum 0.05%, sodium citrate 0.09%, CMC 0.08% and sodium alginate 0.1% can also be added to buffalo milk before boiling to prepare acceptable quality *chhana*.

c) ***Addition of both stabilizer and dilution:*** Treatment of buffalo milk with 0.5% sodium citrate prior to boiling and dilution of buffalo milk with 25% water v/v and coagulation with 1% citric acid solution at 70°C and 5.1 pH produced *chhana* of acceptable quality for sweet making.

d) ***Dilution with water:*** Dilution of buffalo milk (standardized to 4% fat) with potable water @ 30% of milk after boiling and coagulating the same at 70°C using 0.5% citric acid solution produced desirable quality *chhana* suitable for *sandesh* making.

e) ***Coagulation at low temperature:*** Addition of sodium alginate @ 0.05% at 80°C to the standardize buffalo milk (5% fat) followed by heating it to boiling temperature and then coagulating at 40°C with 1% citric acid (pH 5.2) produced soft *chhana* suitable for *rasogolla* making.

Yield of *paneer* and *chhana*

The yield of *paneer* or *chhana* depends on the fat and solid-not-fat content of the milk used for manufacturing, heat treatment given to milk prior to acidification, coagulation temperature, acidity of milk, strength of coagulant and residence time of the coagulated *chhana*-whey mixture before separation of milk solids from whey (these factors affect the moisture, fat and protein retention in the product). Co-precipitation of casein and whey proteins is the simplest way of recovering whey proteins and thus increasing the yield of *paneer* or *chhana*. Heat treatment of milk to 90°C before being cooled to respective coagulation temperatures is necessary to achieve good yield for *paneer* and *chhana*. Generally, yield of *paneer* ranges from 20-22% from buffalo milk and 16-18% from cow milk. The yield of *chhana* from cow milk is 15 to 17% and yield from buffalo milk will be 21 to 23 %.

Factors affecting quality and yield of *paneer*

Type of milk: *Paneer* prepared from buffalo milk will have desirable frying properties, body and texture as compared to cow milk. The cow milk *paneer* is too soft, weak and fragile and during cooking it tend to disintegrate. However combination of cow milk and buffalo milk used for *paneer* preparation at a ratio of 50:50 yields better product than the *paneer* prepared form cow milk alone. *Paneer* made from skim milk has chewy, rubbery and hard body. Cow milk produces *chhana* with moist surface, light yellow colour, soft body, smooth texture and mildly acidic flavour which is more suitable for sweets preparations compared with buffalo milk *chhana* which contains hard body and coarse texture, white in colour and greasy surface. Sweets prepared from buffalo milk *chhana* are hard, coarse and less spongy. Goat milk can also be used producing acceptable quality of *sandesh* and *rasogolla*, but the typical flavour associated with goat's fat is retained in *chhana* and *rasogolla* made there from.

Quality of milk: To obtain *paneer* or *chhana* of good quality, the milk must be fresh and free from off falvours. Growth of psychotropic organisms should be minimized to restrict the off-flavour development. Acidic milk having a titratable acidity of more than 0.20% lactic acid yields a product of inferior quality. The milk with COB positive and low acidity (sweet curdling) is not suitable for *paneer* or *chhana* making. *Paneer* or *chhana* made from such milk has weak body and texture, more moisture, acidic smell and not safe for human consumption. Minimum 3.5 to 4% fat

in cow and 5% fat in buffalo milk gives a satisfactory body and texture in *chhana*. Lower than 3.5% fat leads to hard body and coarse texture while higher fat level results in greasy surface. Addition of neutralizer to slightly acidic milk helps in getting *chhana* suitable for *sandesh* and not for *rasogolla*. Milk with 0.25-0.28% lactic acid can be utilized for *chhana* by adding 0.2% Sodium citrate followed by thorough washing of the coagulum.

Type, strength and temperature of coagulant: Yield of *paneer* or *chhana* and moisture retention are directly influenced by the type and concentration of the acid and the mode of delivery and blending into the hot milk. Citric acid is generally used as a coagulant. Lactic acid or their salts (calcium lactate), tartaric acid, sour whey are also used as coagulants. Lemon or lime juice or vinegar imparts a typical flavour to the product. One percent solution of citric acid yields good quality of *paneer*. Sufficient acid is added gently and quickly blended with the milk (within 1 minute) to reach ideal pH of coagulation. Normally 1.8 to 2.0 kg citric acid is required for 1000L of milk coagulation High acid concentration imparts acid flavour, hardness and causes greater solids loss. Lactic acid produces granular *chhana* fit for rasogolla making. Citric acid gives pasty texture suitable for sandesh making. However, citric acid is also used by many manufacturers for *rasogolla* preparation. Use of calcium lactate as coagulant for *chhana* making at home is very common in West Bengal. Calcium lactate produces *chhana* with bright white colour, soft body and smooth texture and pleasant flavour. This *chhana* can be used for sandesh preparation. Low acid strength (0.5%) results in very soft body and smooth texture suitable for *rasogolla* but unsuitable for *sandesh*. The optimum strength of coagulant should be between 1 to 2% citric or lactic acid to produce good quality *chhana* suitable for making both *rasogolla* and *sandesh*. Addition of 6% solution of calcium lactate to cow milk produces most satisfactory quality *chhana*. Generally 2 to 2.5 g of citric acid or 2.5 to 3.9 g of lactic acid or 6 to 12 g of calcium lactate is required for complete coagulation of a kg of fresh milk. The quantity of coagulant required is dependent on the type of milk (590 ml of sour whey is required per kg of milk) and the temperature of coagulation.

Heat treatment of milk: This is one of the technological requirements of the process which affect the sensory and microbiological quality of *paneer*. The objective of heating the milk is to prepare the milk for rapid iso-electric precipitation, control the moisture content, develop typical body and texture, create conditions conducive to the destruction of pathogenic and other microflora present

in milk and ensure safety as well as keeping quality of the final product. The milk is heated to 90°C without holding or 82°C for 5 minutes in order to maximize the total solids recovery. Whey proteins especially β-lactoglobulin and α-lactalbumin form a complex with κ-casein and retain with the curd thus increase the yield of the product. The high heat treatment imparts desirable cooked flavour by controlled liberation of sulphydryl compounds.

Coagulation temperature: It influences the moisture content of the *paneer* and *chhana*. An increase in temperature from 60°C to 86°C decreases the moisture in *paneer* from 59 to 49%. At 70°C, *paneer* has the best organoleptic and frying quality in terms of shape retention, softness and integrity. Whereas, *chhana* of satisfactory quality is prepared when milk is coagulated at 80°C and the coagulation is completed within a min. The amount of coagulant required for complete coagulation of milk is increased with lowering of coagulation temperature. As the coagulation temperature decreases the moisture content in *paneer* or *chhana* increases resulting in softer body and smooth texture. Whereas, at higher temperatures total solids recovery is more in the product but yield is less. Higher temperatures also give graininess and hardness to product.

pH of coagulation: For better product quality and maximum recovery of solids in *paneer*, optimum pH of coagulation of buffalo milk at 70°C is 5.30-5.35. The moisture retention in *paneer* decreases with the fall in pH and consequently the yield also decreases. When coagulation pH is more than 5.35, *paneer* obtained will be very soft with fragile and crumbly body. Optimum pH of coagulation is 5.2, when cow milk is used for *paneer* preparation. The optimum pH of coagulation for preparation of *chhana* from cow milk is 5.4 and from buffalo milk 5.7. When calcium lactate is used as a coagulant, optimum pH of coagulation for *chhana* manufacture from cow milk is 5.85.

Speed of Stirring: Higher speed of stirring during coagulation reduces the moisture content in *paneer* or *chhana* and increases hardness, whereas for lower speed of stirring the reverse holds true (optimum speed of stirring is 40-50 rpm).

Method of straining: Delayed straining produces a soft and smooth texture in *chhana* than immediate straining. Delayed straining gives a higher proportion of moisture, yield, recovery of milk solids and lower hardness. Delayed straining is recommended when *chhana* is prepared from buffalo milk.

Packaging and shelf-life

Paneer and *chhana* are extremely perishable milk products due to their high moisture content. At room temperature, their shelf-life is less than 24 h. Under refrigeration the shelf life can be extended up to few days. Polyethylene pouches, cryovac films, co-extruded laminates, retort pouches are used for packaging of *paneer* and *chhana*. Vacuum packaging of *paneer* in laminated pouches increased the shelf-life to about 30 days at 6°C. *Paneer* packaged in laminates (EVA/EVA/PVDC/EVA) under vacuum and heat treated at 90°C for one minute increased the shelf-life of up to 90 days under refrigeration. *Paneer* packed in tins along with water/ brine and sterilized in an autoclave at 15 psi for 15 minutes can be stored for 4 months. *Paneer* dipped in 5% brine solution hada shelf-life of 22 days at 8-10°C. The salting at the time of dipping into chilled water can be used in extending the shelf-life of *paneer*. Dipping in benzoic acid (1200 ppm) increased the shelf-life of *paneer* to 40 days at refrigerated temperature and 20 days at 37°C. Addition of sorbic acid to milk (0.15%) and subsequent wrapping of *paneer* in sorbic acid coated waxed paper increased the shelf-life of *paneer* to 36 days at room temperature.

Most of the *chhana* produced in the country is used for making *chhana* based sweets. There is no special packaging material prescribed for *chhana* as most of the time it is sold in bulk. Polyethylene bags are widely used for packaging of *chhana*. However, vegetable parchment paper, tin cans, cellulose film, LDPE, aluminum foil /LDPE laminates were also used for packaging of *chhana*. However, the methods employed for shelf-life extension of *paneer* can be adopted for *chhana* also.

*****

Cleaning, Sanitation and Hygiene Maintenance of Dairy Processing Equipment

Ganga Sahay Meena

Scientist (Senior Scale), Dairy Technology Division, ICAR-NDRI, Karnal-132001

1. Introduction

Fresh milk is almost sterile during milking process but later on it acts as an ideal growth medium for human and microorganisms. As soon as raw milk drawn from udder and comes in the contact of environment, milking persons and utensils, its contamination starts with spoilage and pathogenic micro flora. In order to produce and provide safe, nutritionally rich, fresh like milk and milk based products to the consumers, excellent quality raw milk is required. As milk is highly perishable food item which has every chance of getting contaminated with number of microbial species, foreign materials etc. starting from its production, collection, conveying, processing and storage from plant personnel, packaging material and environmental factors. Safe milk and milk products which is the right of the consumers can only be produced through the applicability and maintenance of efficient cleaning, sanitization and hygiene practices governed by very stringent rules of different national and international authorities. Presently it is well known fact that the excellent quality milk and milk products cannot be produced from inferior quality milk and at the same time the same milk which is usually considered as a “nectar of life or complete food” can acts as a carrier as well as transmitter of pathogenic microbes (which are capable to induce severe outbreaks) into human if mandatory preventive measures not being applied. The contamination of milk during its production, collection, conversion into various milk products, distribution followed by their consumption can be prevented by adopting adequate cleaning, sanitization and hygiene maintenance practices at each step starting from the selection of proper milk collection strategies, plant layout and design, processing steps and equipments, storage and distribution. Number of different equipments (product identical) like milking machine, milk cans, bulk milk coolers, insulated tankers, plunger, dump tanks, pumps, pipes, storage silo and tanks, cream separator, pasteurizer, homogenizer, evaporator and drier and so on always remain in close contact of milk during its processing. In short, basic fundamentals of cleaning, sanitization and hygiene maintenance for some of these equipments with the necessity and importance are being discussed here.

2. Cleaning

All equipments or its surface to which milk was exposed at any stage from its production to utilization must be properly cleaned and sanitized before its next use. Cleaning is the process in which "**complete removal of food soil is accomplished using appropriate detergent chemicals under recommended conditions from the internal and external surface of the equipment**". Food soil can be defied "**as unwanted matter on food-contact surface**s". Initial source of this soil is the product which is being processed. It can be as simple as residue of product itself or just dirt and at the same time it can contain fat, protein, carbohydrates, minerals and water in their natural form or in their modified/interacted form like heat precipitated proteins, caramelized carbohydrates, milk and water stone i.e. **white or grayish film accumulated slowly over the unheated equipment surface as the result of inadequate cleaning and use of hard water or their combination**. Usually addition of sodium carbonates in hard water results in the precipitation of calcium and magnesium salts. Some of this precipitate remains intact to equipment after cleaning and forms a film over equipment surface called water stone. Heat denaturation of protein present on the equipment surface or absorbed by other components results in the formation of milkstone quickly on heated surfaces. This soil can be visible or invisible, basically it of two types: (a) water soluble like sugar, starches and salts easily cleaned by water and (b) water insoluble which is further divided in organic (animal or vegetable originated like fats, grease, protein, starch and carbohydrates and difficult to clean if subjected to very temperatures) and inorganic/mineral (mainly derived from earth crust like water hardness, lime scale and milk stone) soil. Typical properties of different types of food soils are presented in Table 1.

Table 1: Properties of various food soils

Surface Deposit	Solubility	Ease of Removal	Heat-Induced Reactions
Sugar	Water soluble	Easy	Carmelization
Fat	Alkali soluble	Difficult	Polymerization
Protein	Alkali soluble	Very Difficult	Denaturation
Starch	Water soluble, Alkali soluble	Easy to Moderately Easy	Interactions with other constituents
Monovalent Salts	Water soluble; Acid soluble	Easy to Difficult	Generally not significant
+Polyvalent Salts	Acid soluble	Difficult	Interaction with other constituents

(Schmidt, 2012)

Under specific conditions, bacteria, yeasts and molds can form invisible films known as biofilms on the equipment surfaces. These biofilms are usually difficult to remove and needs cleaner as well as sanitizers with strong oxidizing properties for their removal otherwise it will continuously act as a source of product contamination.

2.1 Why cleaning?

Proper cleaning of dairy equipment reduces the chance of product contamination at each step by reducing the high initial load of micro-organism through removal of their available nutrients. Next, it left these microbes unfed without protection so they can easily destroyed by sanitization and disinfection. It promotes clean and tidy environment that improves operator's moral/confidence and helps to maintain safe work place, creates cleaner production area, prevent or avoid accidents. Moreover, distinctly it increases the life of equipment by increasing plant efficiency, improving process economy and profit of the organization. For example, efficiency of milk pasteurizer reduces with increase in process time due to scale deposition on its heat exchanger plates and the same can be regained after its adequate cleaning.

2.2 Cleaning Agents

Cleaning agents are mixture of several chemical compounds employed for a particular function to perform like washing of floors and walls, used in cleaning-in-place (CIP) etc. Good cleaning agents must be economical, nontoxic, noncorrosive, noncaking, nondusting, easy to measure or meter, stable during storage, and easily and completely dissolved. Selection of these agents for a particular task needs specialized technical knowledge and their requirement varies with type of soil to be removed from how much area of a particular equipment. They are mainly used to reduce surface tension of water (common cleaning medium) which results in the dislodging and loosening of soil followed by flushing away of these suspend soil particles. Usually, fats, oils, greases, and proteins can be removed with alkaline cleaners at pH $\geq$11.They are classified as strong, heavy duty and mild alkaline and employed for a particular use. Acid based cleaning agents are the blend of phosphoric, nitric, sulfuric and sulfamic acid used to remove encrusted surface materials and dissolve mineral scale deposits. Organic acids like citric, tartaric, sulfamic and gluconic acids not corrosive to skin can be rinse easily and are excellent water softeners. These are also divided as strong (hydrochloric, hydrofluoric, sulfamic, sulfuric and phosphoric acids) and mild

(levulinic,hydroxyacetic, acetic, and gluconic acids) acid based cleaning agents. Moreover, the optimum performance of different cleaning agents is depends on several other important factors **like time, mechanical action, concentration and temperature**. Optimal cleaning guides for dairy processing equipment are shown in Table 2.

Table 2: Optimal Cleaning Guides for Dairy Processing Equipment

Cleaning Applications	**Cleaning Compound**	**Cleaning Medium**	**Cleaning Equipment**
Plant floors	Most types of self-foaming,or foam boosters added to most moderate to heavy-duty cleaners	Foam (high-pressure, low-volume should be used with heavy fat or protein deposits)	Portable or centralized foam cleaning equipment with foam guns for air injection into the cleaning solution
Plant walls and ceilings	-do-	foam	-do-
Processing equipments and conveyors	Moderate to heavy-duty alkalis that may be chlorinated or non-alkaline	High pressure low volume spray	Portable or centralized high-pressure, low volume equipment, spray should be rotary hydraulic
Closed equipments	Low-foam, moderate to heavy-duty chlorinated alkalis with periodic use of acid cleaners as follow-up brighteners and neutralizers	CIP	Pumps, fan or ball sprays, and CIP tanks

(Marriott and Gravani, 2006)

2.3 Cleaning methods

Equipment cleaning can be accomplished in various ways: (a) Mechanical Cleaning: Often referred to as clean-in-place (CIP), requires no disassembly or partial disassembly- choice of modern automatic plants, (b) Clean-out-of-Place (COP):Can be partially disassembled and cleaned in specialized COP pressure tanks, (c) Manual Cleaning: requires total disassembly for cleaning and inspection. Each type of cleaning has its own merits and demerits.

Cleaning of dairy equipment must be carried out as instructed by the equipment manufacturer. To get desired cleanliness the same operation must be repeated without by-passing/ duration shortening i.e. accurate temperature and concentration of cleaning/ sanitization solution with proper time duration are pre- requisite of efficient cleaning. This means that the sequence must be

exactly repeated after every run. The cleaning cycle in a dairy industry includes following common steps:

- Product residue should be recovered by scraping, drainage and expulsion with water or compressed air
- Loose dirt/ soil should be removed with pre-rinsing with water
- Cleaning with specific detergent
- Rinsing of detergent residues with clean water
- Disinfection of plant surface (by heating or with chemical agents), final rinse of the equipment with microbiologically safe water.

A CIP program for a pasteurizer circuit can consist of the following stages (Tetra Pak, 1995):

- Rinsing with warm water for about 10 minutes
- Circulation of an alkaline detergent solution (0.5 – 1.5%) for about 30 minutes at 75°C
- Rinsing out alkaline detergent with warm water for about 5 minutes
- Circulation of (nitric) acid solution (0.5 – 1.0 %) for about 20 minutes at 70°C
- Post-rinsing with cold water
- Gradual cooling with cold water for about 8 minutes
- Disinfection by circulating hot water at 90 – 95°C for 10 –15 minutes after the returning temperature is at least 85°C.

3. Sanitation, what it is?

Sanitation was originated from *Sanitas* (Latin word) having meaning "health" but the same word has another meaning "creation and maintenance of hygienic and healthful conditions" in food industry." Now a days, it is considered as a joint venture of principles of design, development, execution, maintenance, restoration, improvement of hygienic practices and conditions. It is applied for the creation of hygienic practices intended to continue a clean and healthy environment from food production to storage. It is usually applied after cleaning operation for the complete elimination of all types of bacteria.

3.1 why sanitation?

Properly cleaned and sanitized equipment and buildings are crucial for the production, storage and distribution of quality dairy products. Product can get contaminated with in new and well-designed

plants if proper sanitary practices are not adopted and with their routine practice, quality product can be produced in old plants. Thus, it offers numerous benefits for public and business agencies. Its main focus is to prevent the major based safety incidents to happen in future. Some of the example of such incidents is presented in Table 3.

Table 3: Major Food Safety Incidents

Agent	Food	Effect
S. enteritidis	Ice cream	~224,000 ill
E. coli 0157:H7	Hamburgers	732 ill, 4 deaths
Benzene	Mineral water	Worldwide recall of 160 million bottles
L. monocytogenes	Hot dogs	101 ill, 21 deaths
Allergens	Many foods	35–40% of U.S. population have food allergies; 150–200 people die each year
Glass	Bottled beer	15.4 million bottles were recalled, destroyed, and replaced

(Marriott and Gravani, 2006)

3.2 Commonly used sanitizers in dairy industry

Although several sanitizers are available with different origin and varying germicidal properties yet those which are most frequently being used in dairy plants includes steam, hot water, and chemical sanitizers. In steam sanitizing, steam is subjected and maintained on the equipment surfaces for desired time duration 15 minutes/80 ^{0}C, outgoing condensate temperature. It has limited utility as difficult to maintain, high energy cost and dangerous in comparison to sanitizing methods so usually recommended. The International Dairy Federation recommends circulation of hot water 85℃ for 15 minutes for pasteurizer sanitization. Proper combination of time and hot water temperature is essential for this method. For enclosed system, minimum circulation for 15 minutes of 77℃ water or more than 5 minutes circulation at 94℃ water temperature was recommended by FDA. In chemical (chlorine, iodine etc.) sanitization, sanitizing solution of desired concentration is first made and then kept in the contact of equipment surface by circulation for 2-5 minutes with slight back pressure in the pipe lines. It can also be applied as fogging, spraying and with help of brushes. Properties of commonly used sanitizers are represented in Table 4.

Table 4: Characteristics of commonly used sanitizers and application of chemical sanitizers

Characteristics	Steam	Iodophors	Chlorine	Acid	Quats
Germicidal efficiency	Good	Vegetative cells	Good	Good	Somewhat selective
Yeast destruction	Good	Good	Good	Good	Good
Mold destruction	Good	Good	Good	Good	Good
Toxicity use dilution	—	Depends on wetting agent	none	Depends on wetting agent	Moderate
Shelf strength	—	Yes	Yes	Yes	Yes
Stability stock	—	Varies with temperature	Low	Excellent	Excellent
Use	—	Varies with temperature	Varies with temperature	Excellent	Excellent
Speed	Fast	Fast	Fast	Fast	Fast
Penetration	Poor	Good	Poor	Good	Excellent
Film forming	No	None to slight	None	None	Yes
Affected by organic matters	None	Moderate	High	Low	Low
Affected by other water constituents	No	High pH	Low pH and iron	High pH	Yes
Ease of measurement	Poor	Excellent	Excellent	Excellent	Excellent
Ease of use	Poor	Excellent	Excellent	High foam	High foam
Odor	None	Iodine	Chlorine	Some	None
Taste	None	Iodine	Chlorine	None	None
Effect on skin	Burns	None	Some	None	None
Corrosive	No	Not to SS	Extensive on mild steel	Bad on mild steel	None
Cost	High	Moderate	Low	Moderate	Moderate
Chemical Sanitizer Applications					
Sanitizer	*Application*				
Chlorine	All food-contact surfaces, spray, CIP, fogging				
Iodine	All food-contact surfaces, approach as a hand dip				
Peracetic acid	All food-contact surfaces, CIP, especially cold temperature and carbon dioxide environments				
Acid anionics	All food-contact surfaces, spray, combines sanitizing and acid rinse into one operation				
Quaternary ammonium compounds	All food-contact surfaces, mostly used for environmental control; walls, drains, tiles				

(Marriott and Gravani, 2006)

4.0 Hygiene control of dairy equipment

Main objective of dairy equipment hygiene is to ensure the consistent dairy turn-out of safe and clean products as per the public health laws and to preserve the keeping quality of dairy products

to enhance consumer's faith in these products. It is affected by several factors like dairy building, material and construction of the equipment, personnel, water quality, cleaning practices and laboratory control so continuous monitoring of these factors is highly required to get desired degree of hygiene. Floors of processing area must be constructed with a material which is impervious to water, should have smooth finish, proper slope for efficient drain. Walls should be of at least 4 meter height, smooth with cleanable surface. Milk reception area should be at certain distance from processing area. Sufficient light, proper ventilation and enough space for cleaning of equipments must be provided at each place of dairy plant. Personnel hygiene is mandatory which can be maintained by proper training, education and written instructions. Water quality intended for cleaning should be at par with microbial standards. Its hardness plays a crucial role in scale formation over the equipment surfaces and divided in four groups i.e. very hard (>180 ppm or mg/L), hard (120-180 ppm), moderately hard (60-120 ppm) and soft (0-60 ppm). For proper cleaning and sanitization to maintain desired hygiene, sanitary piping and fitting must be used as per 3-A sanitary standards to overcome the specific cleaning problems.

5.0 Conclusion

Plant layout and construction, equipment surface, quality of air and water and hygiene of dairy workers affect microbial contamination and end product quality of the product. To provide microbiologically safe, nutritionally rich, sensorial acceptable dairy products with naturally fresh like attributes to the end users, proper cleaning, sanitization and hygiene practices must be strictly applied at each step of production, processing, storage and distribution.

6.0 Suggested Reading

Bylund, G. Dairy processing handbook, Tetra Pak Processing Systems AB, Lund, Sweden, (1995).

Holley, R. A. and Jakubowski, J. (1993 revised), http://phpa.dhmh.maryland.gov (Internet document, Accessed on 11.11.2013)

Marriott, N.G. and Gravani, R.B. Principles of Food Sanitation, Ed. 5, Springer Science+Business Media, Inc., USA, (2006).

Rice, E. B., WHO monograph on Hygiene control of dairy equipments, http://whqlibdoc.who.int (Internet document, Accessed on 11.11.2013)

Schmidt, R. H. (2012 revised). Basic Elements of Equipment Cleaning and Sanitizing in Food Processing and Handling Operations. http://edis.ifas.ufl.edu/fs077

Tamime, A. Cleaning-in-Place: Dairy, Food and Beverage Operations, Ed. 3, Blackwell Publishing Ltd, UK, (2008).

*****

Packaging of Dairy Products

Narender Raju Panjagari[1] and Sangita Ganguly[2]

[1]Scientist (Senior Scale), [2]Scientist
Dairy Technology Division, ICAR-National Dairy Research Institute, Karnal

1.0 Introduction

Dairy products contain essential and non-essential nutrients required for the growth and development of human beings. They are highly perishable commodities and serves as a very good media for the growth of many spoilage causing microorganisms. Hence, there is an obvious need to preserve our precious food sources. Food packaging is an external means of preservation of food during storage, transportation and distribution. Hence, it forms an integral part of the product manufacturing process. Food packaging performs four major disparate functions such as containment, protection, convenience and communication. In pursuit of achieving these goals, many materials have been discovered by man for use as food packaging materials. They include wood and paper, glass, metals (such as tin, aluminium), plastics, composites, etc. The inherent properties of these packaging materials make them either highly suitable or unsuitable for a particular food product. Hence, a packaging material has to be judiciously chosen depending upon the nature of the product, availability, machinability, cost, etc. In the present article, an overview of the materials suitable for dairy products packaging and prominent packaging techniques have been presented.

2.0 Paper and Paper-Based Materials

Paper and packaging is a natural pair. Paper is the most important packaging material and packaging is an important use of paper. Paper is a generic term encompassing a broad spectrum of materials derived from cellulosic fibers. It is the oldest packaging material and the most versatile. Pulp is the fibrous raw material used for the production of paper and paper- based products such as paperboard, corrugated board, etc. The distinction between paper and paperboard is not always very clear, but paperboard is heavier and more rigid than paper. Usually, all paper sheets which are greater than 12 divisions thick when measured by a micrometer (300 µm or 1200 gauge or 0.012 inch) are classified as paperboard. Some important paper and paper-based packaging materials used in dairy and food industry are described below:

2.1 Kraft Paper

Strength is one of the outstanding characteristics of Kraft paper and accounts for its wide use throughout the industry. Four of the more important grades of Kraft paper are: (a) grocer's bag or sack paper, (b) shipping sack paper, (c) wrapping paper, and (d) gumming and asphalting paper. Kraft paper is used for bulk packaging of skimmed milk powder, whole milk powder, whey protein concentrates, whey protein isolates, etc. in dairy industry, usually with a plastic inner lining. Unbleached Kraft retains much of the natural colour of the wood pulp from which it was produced.

2.2 Greaseproof Paper

Greaseproof paper is a translucent machine-finished paper that has been hydrated to give oil and grease resistance. Prolonged beating or mechanical refining is used to fibrillate and break the cellulose fibers, which absorb so much water that they become superficially gelatinized and sticky. This physical phenomenon is called as hydration. Although, they are strictly not "greaseproof" since oils and fats will penetrate them after a certain interval of time, they are often used for packaging butter and similar fatty foods.

2.3 Vegetable Parchment

Vegetable parchment takes its name from its physical similarity to animal parchment, which is made from animal skins. It is free of lint, odour and taste, and resistant to grease and oils. Because of its grease resistance and wet strength, it strips away easily from food material without defibering, thus finding use as an interleaver between slices of food such as meat or pastry. It can be treated with mold inhibitors and used to wrap foods such as cheese.

2.4 Waxed Paper

Waxed papers provide a barrier against penetration of liquids and vapours. Many base papers are suitable for waxing, including greaseproof and glassine papers. The primary purpose of the wax is to provide a moisture barrier and a heat sealable laminant. Frequently, special resins or plastic polymers are added to the wax to improve adhesion and low temperature performance, and to prevent cracking as a result of folding and bending of the paper.

2.5 Folding cartons

Paper is generally termed board when its grammage exceeds 224 gm-2. Folding cartons are containers made from sheets of paperboard (typically with thickness between 300 and 1100 μm),

which have been cut and scored for bending into desired shapes; they are delivered in a collapsed state for assembly at the packaging point. A number of steps are involved in converting paperboard into cartons. Where special barrier properties are required, coating and laminating are carried out. Folding cartons, for example, are used for packing bulk/family-sized ice cream packs. The most common packaging material used for UHT milk is the paperboard laminate carton.

2.6 Corrugated fibreboard

Corrugated board is manufactured from three basic sheets – two liner boards and a central corrugated sheet or medium (flute). These materials can be varied as to weight, type and number and/or height of the corrugations in the fluting medium. The properties of a corrugated board depend largely on the type, number and position of the corrugations. Mostly corrugated fibreboards are used as secondary or tertiary packaging in the distribution and marketing of dairy products (Fig. 1). Different types of corrugated fibreboards viz. (a) single face, (b) single wall, (c) double wall and (d) triple wall are shown in Fig.2.

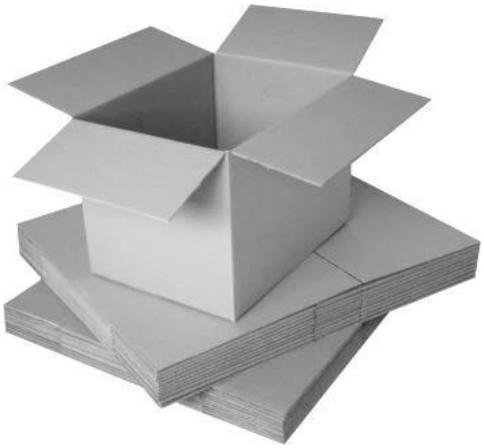


Fig.1. Corrugated Fibreboard

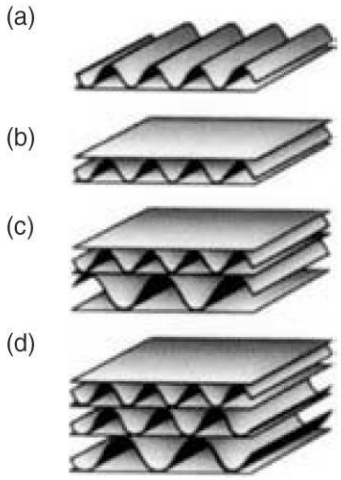


Fig.2 Types of corrugated fibre boards

3.0 Glass Packaging Material

Glass is substance that is hard, brittle and usually transparent. Soda-lime glass is made from limestone (about 10%), soda (about 15%) and silica (about 75%). Lesser percentages of aluminium, potassium and magnesium oxides may be included. When the components are melted together they fuse into a clear glass which can be Readily shaped while in a semi-molten state. The melting of glass is usually accomplished at a temperature of about 1540°C in a very large furnace. For obtaining different coloured glasses various chemicals are added to the melt such as iron oxide

for amber colour, cadmium compounds for yellow colour, etc. Glass containers such as jars, bottles, etc. are made by various methods such as (a) extrusion, cutting and shaping; (b) press and blow or blow and blow; and (c) pressing. Different types of closures are used for closing the containers viz. Simple wrapping without sealing, twist wraps, heat seals, threaded screw closures, etc. Milk for retail sale was traditionally packaged in refillable glass bottles. However, today, single- serve paperboard cartons and plastic containers of various compositions and constructions dominate the market. Presently, sterilized flavoured dairy drinks are marketed in glass bottles by some reputed dairy industries.

4.0 Metal Packaging Materials

Four metals are commonly used for the packaging of foods viz. steel, aluminium, tin and chromium. Tin and steel, and chromium and steel are used as composite materials in the form of tinplate and electrolytically chromium-coated steel, sometimes referred to as tin-free steel. Aluminium is used in the form of purified alloys containing small and carefully controlled amounts of magnesium and manganese.

4.1 Tin plate

The term tin plate refers to low ca material that has good strength, combined with excellent fabrication qualities such as ductility and drawability as well as good solderability, weldability, nontoxicity, lubricity, lacquerability and a corrosion- resistant surface of bright appearance. Tin plate is used for the manufacture of two-piece and three- piece cans (Fig.4). The traditional method for packaging milk powders for consumer's uses three- piece tinplate cans where the atmospheric air is withdrawn from the powder and replaced with an inert gas such as nitrogen prior to seaming the base onto the can.

4.2 Aluminium

Aluminium is the earth's most abundant metallic constituent, comprising 8.8% of the earth's crust, with only the non-metals oxygen and silicon being more abundant. Aluminium is used in the form of foil, tubes or retort pouches in the food industry. Aluminium foil is a thin-rolled sheet of alloyed aluminium varying in thickness from about 4 to 150 µm. It is essentially impermeable to gases and water vapour when it is thicker than 25.4 µm. it can be converted into a wide range of shapes and products including semi-rigid containers with formed foil lids, caps and cap liners, composite cans,

laminates containing plastic and sometimes paper or paperboard, etc. Aluminium foil has an important role as light and gas barrier in the 5 or 7 layered laminate used for packaging of UHT milk.

5.0 Plastic Packaging Materials

Plastic is derived from the Greek plastikos, meaning easily shaped or deformed. Food industry is a major user of plastic packaging materials. Plastics are usually divided into two broad categories: thermosetting and thermoplastic. Polyethylene, polystyrene, polypropylene, polyvinyl chloride, etc. are thermoplastic type of plastics. Mostly thermoplastics are being used for packaging of dairy products.

5.1 Polyolefins

Polyolefins form an important class of thermoplastics and include low, linear and high density polyethylenes (PE) and polypropylene (PP). Industry commonly divides polyethylenes into two broad categories based on their densities: high density polyethylene (HDPE) and low-density polyethylene (LDPE). The properties that make polyethylenefilm a popular packaging medium in dairy industry are its low price, nontoxic, excellent heat-sealing property, flexibility, pleasing appearance and softness, chemical inertness. Low-density polyethylene (LDPE) accounts for the biggest proportion of the plastics used in food packaging due to its versatility. LDPE film accounts for a little over 50% of total PE in this sector because it provides strength, gloss, flexibility, and the good clarity. It can be extruded into film, blown into bottles; injection molded into closures, extruded as a coating on paper, Al foil or cellulose film, and made into large tanks and other containers. It is easily heat sealable. LDPE film is used for packaging of milk, oil, salt etc. For an equal wall thickness, HDPE gives grater rigidity to bottles than LDPE. HDPE films have a cloudy appearance, occasionally utilized as a liner for the bulk packaging of skim milk powder due to their high strength and barrier properties. Furthermore, HDPE is the most commonly used film as carton liner. However, polyethylene is not suitable for packing foods with strong aromas or the products, which have to be packed under vacuum. Chemically, the polypropylene (PP) is similar to LDPE and HDPE. It is harder than either and has a less waxy feel. It can be converted into film and sheet or can be thermoformed to give thin – walled trays of excellent stiffness. PP has an excellent grease resistance. It has better mechanical strength and less prone to stress cracking than PE. It has poor low temperature performance and impact resistance. The properties of PP can be

altered by orienting the film. The oriented PP (OPP) has better tensile strength, low permeability to water vapour, and oxygen gas. Polypropylene is non-toxic, and extensively used as packaging material for various food products. The advantages of PP are: low cost, good impact strength, process able by all thermoplastic equipment, low coefficient of friction, and good moisture and chemical resistance. The oxygen permeabilities of commonly used polyolefin-based and other plastic films in dairy and food industry are given in Table-1.

Table-1.Permeability of some selected packaging materials

Film Type	Permeability [a]			Water vapour transmission rate (WVTR)[b]
	Oxygen	Nitrogen	Carbon dioxide	
LDPE	7800	2800	42000	18
HDPE	2600	650	7600	7 – 10
Polypropylene, cast	3700	680	10000	10 – 12
Polypropylene, oriented	2000	400	8000	6 – 7
Polypropylene, oriented and PVdC coated	10 – 20	8 – 13	35 – 50	4 – 5
Polystyrene, oriented	5000	800	18000	100-125
Ethylene vinyl alcohol	3 – 5	---	---	16 – 18
Plasticized PVC	500 - 30000	300 - 10000	1500 - 46000	15 – 40
PVdC-PVC copolymer	8 – 25	2 – 2.6	50 – 150	1.5 – 5.0
Nylon-6	40	14	150 – 190	84 – 3100

[a] Gas transmission rates are expressed as mL/m^2/day/atm for 25 μm thick film at 25°C
[b]WVTR expressed as g/m^2/day/atm (38°C and 90% RH)

Source: Fellows (2009)

5.2 Polystyrene

Polystyrene (PS) is amorphous and in pure form, it is very brittle but when blended with chemicals like butadiene and copolymerized with acrylonitrile, it becomes tough. It is relatively cheap and has high water vapour and gas transmission rate, hence also called as “breathing film”. PS is crystal clear, sparkling and is also used for thermoformed cups, traysand glasses for yoghurt, ice cream, meat, soft drinks, etc. However, it is unsuitable for heat sterilization, and deteriorates on exposure to sunlight.

5.3 Polyvinyl chloride

Polyvinyl chloride (PVC) has several overall balanced properties required by the food packaging systems: glass like clarity, good mechanical strength, and resistance to water vapour, gases and chemicals, retention of flavour, excellent printability, and lower weight / volume ratio. Due to these properties, PVC is commonly used for food packaging in various forms like films and sheets, bags/liners, shrinkable tubes/films, skin/blister packs, film laminates, bottles and sachets.

5.4 Polyvinylidene chloride

Polyvinylidene chloride (PVDC) is a polymer based on the vinylidene chloride monomer. The film has excellent water vapour and gas barrier properties, besides outstanding characteristics like retention of odours and flavours, resistance to oils and fats, heat sealing characteristics, non-toxicity, abrasion, and chemical resistance. The laminates comprising of PVDC are widely used for the packaging of baby foods, snacks, chips, powdered soups and sauces, powdered coffee, coffee beans, sweets, biscuits and crackers, and powdered sugar.Saran, a copolymer of vinyl chloride and vinylidene chloride, is extensively used for food packaging.Saran is suitable for the packaging of several traditional dairy products such as sweet meats.

5.5 Nylon film

The unique properties of nylon film are that it has high mechanical strength, high elongation capability, excellent resistance to cutting, perforation, abrasion and bursting, high chemical resistance to oils and fats, outstanding impermeability to gases and vapours, easy printability, easy metallizing. The film can be biaxially oriented, and its properties remain unchanged between –30º to 120º C. The film is used in food packaging, especially where aroma retention is required.

5.6 Polyester

Polyethylene terephthalate (PET) is important polyester used in food industry. The main advantages of polyester films are that they are tough, sterilizable, very clear, chemical resistant, has low water absorption, low moisture vapour permeability, low gas permeability and are used as a laminate base. Its main applications include in metallized films, vacuum and gas packaging, shrink packaging, cured meat, and in boil-in-the-bag applications. This film is of great interest to the food packagers as it contains no plasticizers and is non-toxic.

6.0 Important packaging techniques

6.1 Aseptic packaging

Aseptic packaging can be defined as the filling of a commercially sterile product into sterile containers under aseptic conditions and hermetically seal the containers so that re-infection or contamination is prevented. The prime necessity of an aseptic packaging unit is to prevent recontamination of the sterilized product. Thus, the principal consideration in this regard includes sterilization of the filling machine and packaging material by suitable physical and/or chemical means and maintaining aseptic barriers during filling and sealing. A schematic representation of aseptic packaging process is shown in Fig. 3.

The basic operations in aseptic packaging mainly consists of the following:

- Heating the product to sterilization temperatures (140-150°C for no hold to few seconds).
- Maintaining the sterility of the products till they are cooled/packed.
- Filling into sterile containers and sealing aseptically.

The major reasons for using aseptic packaging are:

a) To enable the containers to be used which are otherwise unsuitable for in-package sterilization.
b) To take advantage of HTST sterilization processes, which are thermally efficient and generally give superior quality compared to those processes involving lower temperatures and longer times.
c) To extend the sterilization of products at normal temperatures by packaging them aseptically.

The aseptic packaging system must be capable of filling the sterile product in an aseptic manner and of sealing the container hermetically to maintain the sterility of product throughout the storage and distribution process. The major requirement of an aseptic packaging unit is to prevent recontamination of the sterilized product. The aseptic packaging system should be capable of meeting the following four criteria:

a. Able to be connected to the processing system in a manner that enables aseptic transfer of the product to take place.
b. Able to be effectively sterilized before use.

c. Able to carry out the filing, sealing and critical transfer operations in a sterile environment.
d. Able to be cleaned properly after use.

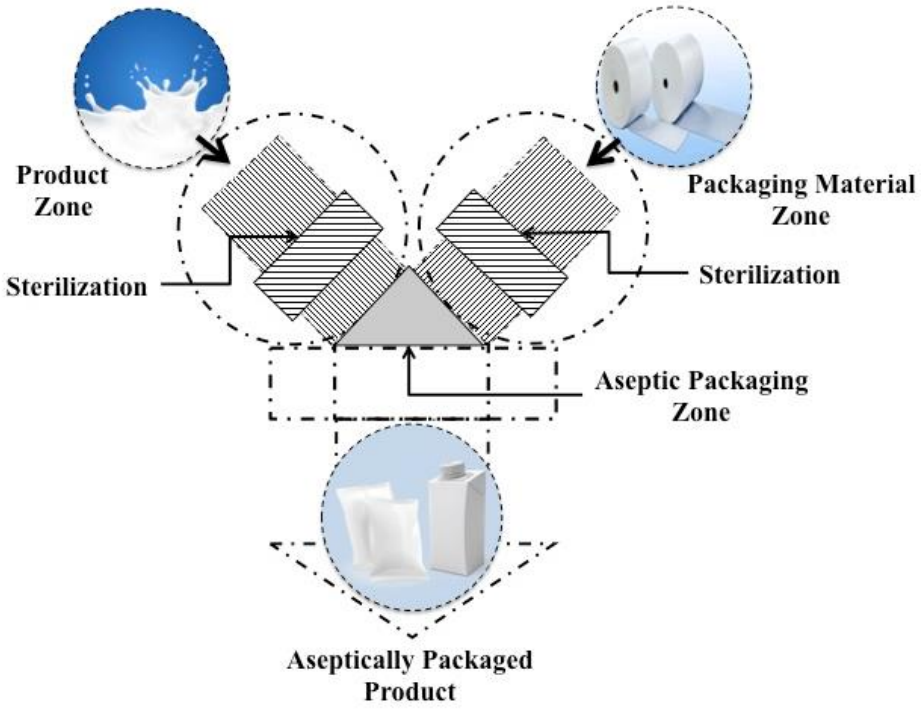


Fig. 3. Schematic representation of aseptic packaging process

The type of packaging material used is influenced by the nature of the product, the cost of both the product and the package, and the preferences of the consumers. Although the most widespread aseptic package for aseptic products is the paperboard laminate carton, five major categories of aseptic packaging forms are available namely (a) carton system, (b) can system, (c) bottle system, (d) sachet and pouch system, and (e) cup system

The carton material consists of layers of unbleached or bleached paperboard coated internally and externally with polyethylene, resulting in a carton that is impermeable to liquids and in which the internal and external surface may be heat-sealed. Such packaging materials are commonly used in aseptic filling systems for milk, cream, fruit juices, soups etc. The filling systems could be either of the following two types: those in which the carton is formed within the filler from a continuous reel of material; and those in which the cartons are supplied as preformed blanks, folded flat, which are assembled into cartons in the filler. The packaging material is mainly composed of printed-paper coated with aluminium foil and several plastic layers (Polyethylene-paper board-polyethylene-aluminium foil-polyethylene). The inner material side of the finished package is

coated with a special layer facilitating the sealing process. The structure of a typical paperboard carton is given in Fig 4. Each layer has a specific function. The outer polyethylene layer (15 g/m^2) protects the ink and enables the sealing process of the package flaps. The bleached paperboard (186 g/ m^2) serves as a carrier of the décor and gives the package the required mechanical strength. The laminated polyethylene (25g/ m^2) binds the aluminium to the paperboard. The aluminium foil (6.3µm) acts as a gas and light barrier. The two inner polyethylene layers (15 g/ m^2) provides liquid barrier.

For a form-fill-seal carton, the packaging material is supplied in rolls that have been printed and creased, the latter is necessary to ease the forming process. The plastic strip is sealed to one edge and the packaging material is sterilized using a wetting system or a deep bath system. In the wetting system, a thin H_2O_2 film (15 to 35% concentration) containing a wetting agent is applied to the inner packaging material surface. The material then passes through a pair of rollers to remove excess liquid and under a tubular electric heater, which heats the inside surface to about 120°C and evaporates the H_2O_2. In deep bath system, the packaging material is fed through a deep bath containing H_2O_2 (35% concentration) at a minimum temperature of 70°C, the residence time is 6 sec. After the squeezer rollers have removed much of the peroxide, both sides of the material are heated with air at a temperature of 125°C to evaporate the peroxide.

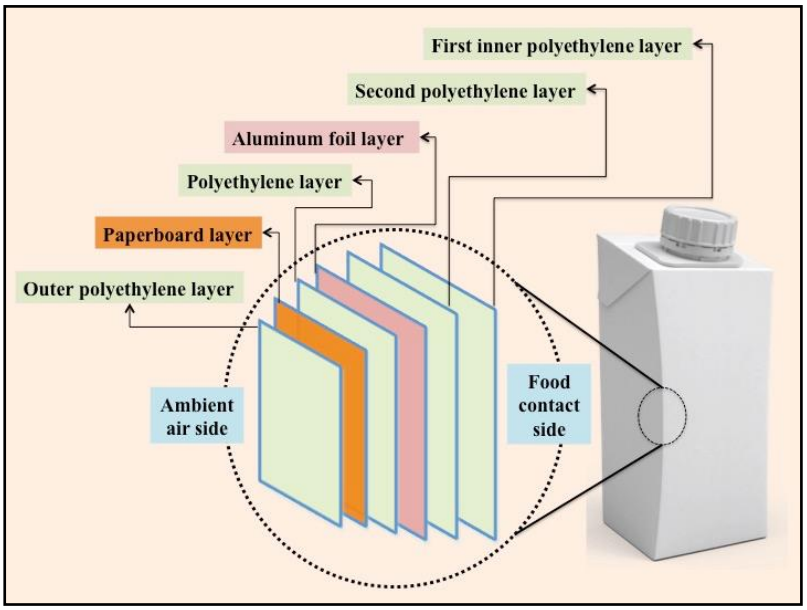


Fig. 4. The structure of a typical laminated carton for aseptic packaging

The sterilized packaging material is fed into a machine where it is formed into a tube and closed at the longitudinal seal by a heat-sealing element. In the process, the strip that was added prior to sterilization is heat sealed across the inner surface of the longitudinal seal to prevent contact between the outside and the inside of the carton. It also provides protection to the aluminium and paperboard layers from the product, which could corrode or swell the layers if such a strip were absent. The tube is then filled with the product and a transverse seal made below the level of the product, thus ensuring that the package is completely filled. Alternatively, the packages may be produced with a headspace of upto 30% of total filling volume by injection of either sterile air or other inert gases. The sterilization, filling and sealing process are all performed inside a chamber maintained at an overpressure of 0.5 atm with sterile air. The system has been illustrated in Fig 5.

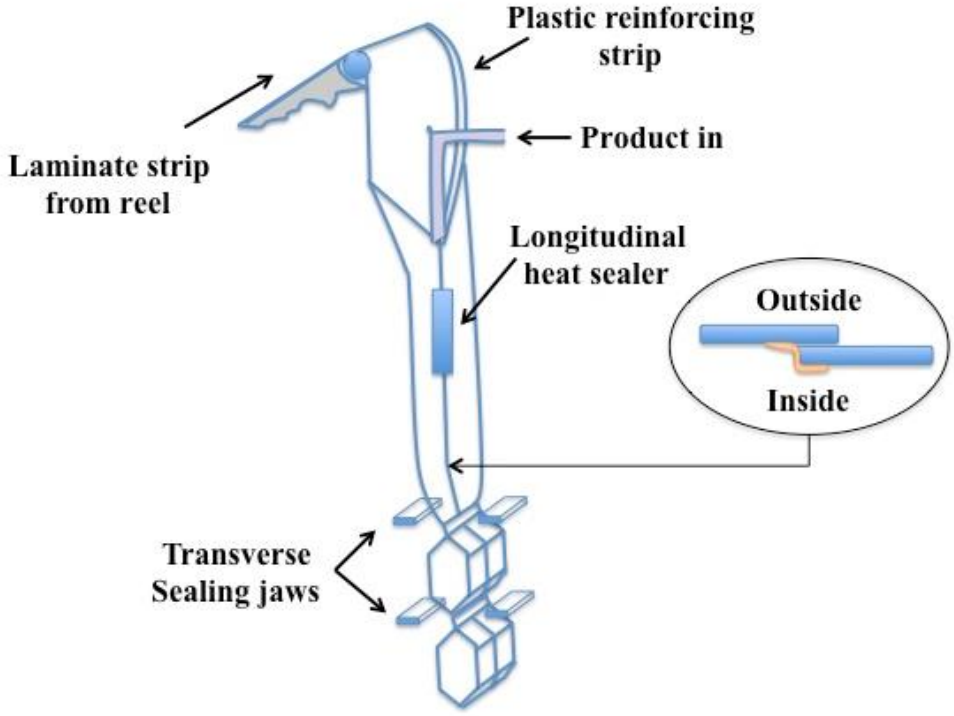


Fig. 5 An illustration of aseptic carton formation from a continuous web
(Redrawn from Robertson (2013))

6.2 Modified atmosphere packaging

The normal composition of air is 78 % nitrogen (N_2), 21 % oxygen (O_2), 0.03 % carbon dioxide (CO_2) and traces of the noble gases. The modification of the atmosphere within the package by reducing the oxygen content while increasing the levels of CO_2 and / or N_2 has been shown to significantly extend the shelf life of perishable foods at low temperature. The modified atmosphere

packaging (MAP) is the technology of producing a gas atmosphere around a product that deviates from ambient air composition by either passive or active methods in order to achieve improved quality and prolonged shelf life. Four packaging techniques are included within this definition namely vacuum packaging, passive MAP, gas-flush MAP and MAP by active packaging. MAP has also been referred to as "*protective atmosphere packaging*" or when used in labeling as "*packaged in a protective atmosphere*". The diagrammatic representation of a dairy product in MAP is shown in Fig. 6.

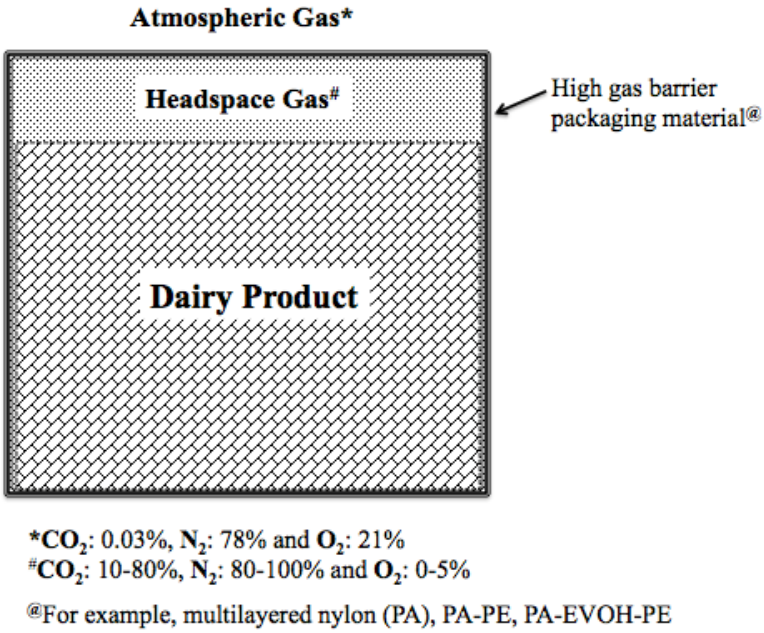


Fig 6. Diagrammatic representation of modified atmosphere packaged dairy products.

The principle of MAP involves the removal of air from the pack and its replacement with a single gas or a mixture of gases by either passive or active methods. The gas mixture used is dependent on the type of product. Passive modification is a slow process. It requires reactions between the food and its surrounding gases to take place, and the package to play the role of a regulator. On the contrary, active modification is faster and can be achieved by gas flushing, vacuum application or by using gas scavengers / emitters. Passive MAP relies on the selective permeability of the packaging materials to different gases and on product respiration, and is traditionally used with fresh and minimally processed fruits and vegetables and only with some selected cheese varieties. Gas-flush MAP involves the establishment of a specific gas composition within the package in a single stage during the packaging operation, by flushing with the selected gas mixture before sealing. Depending on the desired residual O_2, a vacuum operation may be needed prior to gas

flushing. The instant modification of the package atmosphere is the main advantage of gas-flush MAP over the relatively slow passive process. Vacuum packaging, which involves the removal of air from a package without replacement by another gas could also be considered as a type of MAP because the removal of air from the environment itself is a modification of the atmosphere.

One of the important considerations in MAP is defining the optimal gas atmosphere for a food product in a specific packaging design. This optimal atmosphere depends on the intrinsic parameters of the food product (pH, water activity, fat content, type of fat) and the gas / product volume ratio in the chosen package type. The intrinsic parameters will determine the sensitivity of the product for specific microbial, chemical and enzymatic degradation reactions. Products that are susceptible to microbial spoilage due to the development of Gram-negative bacteria and yeasts (e.g. cheese, yoghurt) will be packed in a CO_2 enriched atmosphere as the growth of those microorganisms is significantly retarded by CO_2. In general, oxygen is excluded from the gas mixture. For prolonging the shelf life of products, which are spoiled due to mold growth (e.g. hard cheeses) or due to oxidation, it is essential to package in oxygen-free atmospheres. The use of CO_2 is however limited to its solubility in water and fat. High solubility can cause collapsing of the package when too high CO_2 concentrations are applied. This will especially be the case with food products containing high amounts of unsaturated fat.

Moreover, too high CO_2 concentrations in the atmosphere can lead to an increased drip loss during storage. This can be explained by the pH drop induced by CO_2 dissolving in the water phase of the product, causing a decrease in the water binding capacity of the proteins. Also, when a respiring food is sealed in an impermeable film and in-pack O_2 levels fall to very low concentrations, anaerobic conditions will usually result in undesirable fermentation reactions (undesirable odors and flavors) and a marked deterioration in product quality. In addition, there is a risk of growth of anaerobic pathogens such as *Clostridium botulinum*. Hence, a minimum level of 2 – 3 % O_2 is recommended to ensure aerobic conditions.

6.3 Shrink Packaging

Shrink films, also called as heat-shrinkable films, provide a high degree of free shrink with a controlled level of shrink force over a broad temperature range. Although most plastics exhibit some amount of free shrink and shrink force at elevated temperatures, shrink films are basically

composed of: a) polyvinyl chlorides (PVC and PVC-PVDC copolymers), and b) polyolefins. Usually, these films require temperatures above 100°C to obtain a suitable degree of shrinkage, necessitating the use of hot air tunnels or heat guns. Exceptionally, PVDC copolymer can be shrunk in hot water. Three properties are important when selecting a film for a particular application: (a) wide range of temperature over which a film will shrink and wide softening range, (b) degree of shrinkage (amount of shrinkage may vary from 15-80% depending on polymer composition and manufacturing technique), and (c) shrink tension, which is the stress exerted by the film when it is restrained from shrinking at elevated temperatures. Shrink films are produced by uniaxially/ monoaxially or biaxially orienting a sheet or tube of film by imposing a draw force at a temperature where the film is softened but kept below its melting point, then quickly cooled to retain its physical properties generated during orientation. Orientation occurs between softening point and melting point. The key attributes that are important to shrink films include shrink, sealability, optics, toughness and slip. Shrink properties depends on the onset temperature, free shrink, shrink temperature range and overall package appearance. For sealing properties, one must also consider, ease of trim sealing, trim seal strength, trim seal appearance and thermal lap sealability. For optics, it is important to consider clarity, gloss and haze.

The ultimate goal of shrink packaging is to have a package that is tightly shrunk with no excess material or "ears" on the corners of the finished package. PVC films do not require the same level of temperature control as polyoleofins, since they shrink more easily when exposed to heat. The equipment needed to provide a sharp tightly finished package is a shrunk tunnel. In order to have an adequate shrinkage to occur, the package must be exposed to correct temperature and air flow for proper time.

6.4 Active Packaging

Active packaging is defined as the "packaging in which subsidiary constituents have been deliberately included in or on either the packaging material or the package headspace to enhance the performance of the package system". The two key words are "deliberately" and "enhance". Implicit in this definition is that performance of the package system includes maintenance and often improving the sensory, safety and quality aspects of the food. Hence, in other words, active packaging may also be defined as "packaging that interferes with the internal condition of a packaged food product and changes the condition to extend the shelf life or improve food safety

or sensory properties in order to maintain the quality". Active packaging techniques for food preservation can be divided into three categories: scavengers (absorbers), releasing agents and others. Absorbing systems remove undesirable compounds such as oxygen, carbon dioxide, ethylene, excessive water, taints and other compounds. Releasing systems actively add or emit compounds to the packaged food or into the headspace of the package such as carbon dioxide, antioxidants and preservatives. Other systems include self-heating, self-cooling systems, etc.

6.5 Intelligent Packaging

Intelligent packaging is defined as packaging that contains an external or internal indicator to provide some information about the history of the package and / or the quality of the food. In other words, it refers to a package that can sense environmental changes and in turn informs the changes to the users. Such packaging systems contain devices that are capable of sensing and providing information about the functions and properties of the packaged foods and/or contain external or internal indicator for the active product history and quality determination. These devices can be divided into three groups. The first type is the external indicators, which are attached outside the package and include freshness indicator, time-temperature indicators and physical shock indicators. The second type is the internal indicators, which are placed inside the package either in the headspace of the package or attached to the lid such as gas indicators. The third type of devices is the indicators that increase the efficiency of information flow and effective communication between the product and the consumer. These products include special bar codes that store food product information such as directions for use, consumption date expiration, etc. Product traceability, anti-theft, anti-counterfeiting and tamperproof devices are also included in this category. Indicators are called smart or interactive because they interact with compounds in the food.

7.0 Characteristics of Dairy Products and their Packaging Requirements

Liquid milk and dairy products differ in their composition and hence, their packaging requirements differ. In general, dairy products are prone to spoilage due to sun light, air / oxygen, water vapour and microorganisms. Typical packaging requirements of dairy products are given in Table-4. Hence, while selecting the packaging materials and packaging technique, these things should be kept in mind.

Table-4. Characteristics of Dairy Products and their Packaging Requirements

Classification	Products	Significance	Packaging Requirement
Fluid Milk Products	Toned milk, Double toned milk, Full cream milk, Flavoured milks, etc.	Perishable due to high moisture, ideal for microbes and presence of photosensitive components	Protection against light and oxygen
Dried Milk Products	WMP, SMP, dried mixes, WPC, etc.	Low moisture, high fat and photosensitive	Protection against water vapour, light and oxygen
Fat rich products	Butter, spreads, etc.	High fat with fat soluble vitamins and pleasant aroma	Protection against oxidative and hydrolytic rancidity, aroma protection
Fermented dairy products	Cheese, Kefir, dahi, yoghurt, lassi, labneh, etc.	Beneficial bacteria with characteristic flavours and B-vitamins	Protection against light; oxygen, moisture and gas barrier; aroma protection
Traditional Indian Dairy Products	Burfi, peda, paneer, gulabjamun, rasogolla, ghee, etc.	High fat, low moisture products with characteristic flavours,	Protection against moisture, light, preservation of aroma
Long-life products	UHT milk, Sterilized milk, retort processed products (like paneer curry), canned products (rasogolla, gulabjamun, condensed milks), etc	Sterile, medium to high fat, characteristic flavours with minimum head space in the pack	Protection against microorganisms, light, oxygen, moisture and container surface and preservation of aroma

8.0 Packaging of liquid milk

Milk has been packaged in different types of containers throughout the world. Although from protection point of view, milk could be packaged under rigid packs such as glass bottles and plastic bottles, but for economical and convenience reasons, their use is discouraged. Alternate flexible materials such as plastic films with more or less the same desired functional properties have been evolved. Of the total milk packed, it is estimated that flexible pouches dominate (92%), followed

by bottles (5%) and aseptic packaging cartons (3%). The unique advantages offered by the plastic packages include good barrier properties, visibility of the contents, light in weight, can be used for single-service, are easy to carry home, more economical and attractive due to multi-colour printing and ergonomic designs. Also, the use of plastic containers eliminates noise of the milk bottling plants and during delivery, and also reduces water pollution caused by milk residues and detergents used in the bottle washing process.

Plastic pouches have fast replaced glass bottles for packaging of milk. Flexible pouches have proved to be a safe, quick and cost-effective packaging method with a wide distribution network, providing ease of packaging and handling. Presently, milk is sold in various package forms like pouches, cartons, bags, plastic bottles and jars, etc. The recommended thickness of PE film for one litre pouches shall be not less than 75 microns and for half litre pouches not less than 60 microns. Presently, pasteurized and homogenized market milks such as toned, double toned, standardized, full cream milks, etc. are all packaged in TiO2 pigmented LDPE or LLDPE pouches. Recently, the dairy industry started marketing liquid milks for institutional or catering sales using LDPE or LLDPE pouches with a capacity of 6litres. Although there are no guidelines for the thickness of such packs, the industry uses films of minimum 110 microns. In a form-fill-seal (FFS) machine, the plastic film is formed into a tube, sealed along its length, sealed at the bottom to form a pouch, filled with milk and then sealed at the top. Liquid milk is also packaged in various capacities (500 mL to 4 L) of bottles made from TiO_2 pigmented HDPE or polyethylene terephthalate (PET).

9.0 Packaging of fat-rich dairy products

Cream contains a high percentage of butterfat and moisture which make it susceptible to spoilage. In addition, it must be protected from water loss. The shelf life of refrigerated creams ranges between 1-2 days without proper protection. Packaging helps in extending the shelf life of cream. Both retail and bulk packaging of cream are provided by the industry. Bulk packaging of cream is done for catering or institutional use. Normally polythene bags contained in plastic crates or cardboard cartons are used for bulk packaging. The package size for bulk uses ranges from 5 to 25 liters. Pasteurized cream is packaged in cartons and bottles for retail sale with package size usually being in the range of 100-1000 mL. To improve the barrier properties of plastics packaging for fresh cream, multilayer materials may incorporate an ethylene vinyl alcohol (EVOH) layer. Once filled, the containers are closed with a heat-sealed polyethylene or aluminium foil laminate and

often a clear plastic lid is provided for consumers to reseal the container once opened. In case of retort sterilized cream, tin cans and glass bottles are commonly used packaging formats. The can and glass bottle have been the traditional containers for retort processing, but retortable multilayered laminates containing polyamides (nylon), aluminum foil and polypropylene materials are now available for packaging. The current retail market is dominated by UHT cream (250 mL) packaged aseptically using multilayered laminates similar to those used for UHT milk. Whipped creams and synthetic formulations are sold in aerosol cans and polyethylene tubs with snap-on lid.

Packaging of butter is done in bulk packs of more than 5 kg and in retail packs from 10 g to 5 kg. Various types of machines are used, depending on the type of packaging. The machines are usually fully automatic, and both portioning and packaging machines can often be reset for different sizes such as 250 and 500 g or 10 and 15 g. The wrapping or packaging material must be greaseproof and impervious to light, flavouring and aromatic substances. It should also be impermeable to moisture, otherwise the surface of the butter will dry out and the outer layers become more yellow than the rest of the butter. Butter is usually wrapped in aluminum foil for retail marketing. Parchment paper was once the most common wrapping material (still being used) which has now been largely replaced by the less permeable aluminum foil. After wrapping, the pat or bar packets continue to a cartoning machine for packing in cardboard boxes. Bulk packaging of butter is done in boxes, tubs or casks. Mostly, HDPE liners are used for wrapping the butter and corrugated fiberboard boxes of multiple plies (3, 5 or 7 ply) are used as secondary packaging material. Tubs made of HDPE or PET with press-on lids are also commonly used for packaging of butter.

Ghee has a long keeping quality and can be stored for 6 to 12 months under ambient temperature. Minimum or no head space should be provided while filling of *ghee*. It is better to fill the product upto the brim of the container to attain a long shelf life. Glass bottles, food grade plastic containers such as high density polyethylene pouches, laminates with metallic layer support (aluminum) and tin cans are in use for packaging of *ghee*. Majority of dairies in public as well as private sector are using lacquered or even unlacquered tin cans of different sizes (250 g, 500 g, 1 kg and 15 kg) for packaging of *ghee*. The advantages of using tin cans are manifold. The only drawback of tin cans is their high cost. Regular tin pack sizes available in the market are 15, 5 and 1 L and 500 mL. Glass bottles also provide excellent protection, as they do not react with the food material and can be used for high-speed operations; but are not in much use for packaging of ghee because of their

fragility and high weight. Since *ghee* is an expensive commodity and all consumers cannot afford to buy large size packs, some of the producers have started packaging *ghee* in glass bottles for retailers in sizes of 100 to 500g. Semi-rigid plastic containers are replacing tin plate containers and all have good scope for packaging of *ghee* and butter oil. These are mainly made from HDPE or PET. The advantages of using these containers are that they provide a moderately long shelf life (not as long as tin cans), are lightweight, economical and transport-worthy. Blow moulded bottles made up of HDPE, PET or PVC, lined cartons and multi-layered laminates are available for packaging of *ghee*. Blow moulded HDPE is available in the form of bottles (200, 400 g), jars (1 kg and 2 kg.), and jerry cans (2 kg, 5 kg, and 15 kg). PET bottles have excellent clarity, are odour free and have gas barrier properties. Limited quantities of ghee are also packed in flexible pouches (less than 1 kg pack size) and bag-in-box containers (1 kg). The most attractive feature of packaging ghee in flexible pouches is that they are most economical than any other packaging system. The selection of a laminate or a multilayer film is governed primarily by the compatibility of the contact layer, heat sealability, heat-seal strength and shelf life required apart from aroma, grease, water vapour, oxygen and light barrier properties. Laminated pouches made of PVDC-Al foil-PP are suitable for long term storage of *ghee*. Self-standing laminates are used for 250 mL and 500 mL packs which are barrier to moisture, air and light.

10.0 Packaging of fermented dairy products

Dahi is a popular set-type fermented dairy product in India, whereas yoghurt is the best known of all cultured-milk products and the most popular worldwide. *Dahi* and yoghurt are highly perishable products and packaging protects them during handling and helps to maintain their physicochemical, nutritional and sensory characteristics. Since, these products are soft in nature with firm texture especially in set-type products, they require rigid or semi-rigid containers such as glass or plastic containers, while for stirred, pourable products or beverages flexible packaging materials in the form of paperboard cartons and plastic pouches could be used. Plastic materials such as high-density polyethylene (HDPE), polypropylene (PP), polystyrene (PS) and polyvinyl chloride (PVC) provide desired strength to the packaging materials for yoghurt and *dahi*. The PS containers, especially the high-impact PS (HIPS) which are now extensively used by dairy industry for packaging of dahi and yoghurt are very clean in appearance, gives good shining look, are light in weight and unbreakable. But the problem associated with PS and PP cups is wheying-off in set-

type products such as *dahi* during storage. Preformed and cut aluminum foil and PE or PS laminates of about 100 mm diameter with a pull-tab for easy opening is usually used as lids to seal *dahi* and yoghurt cups or tubs. Currently, for institutional sales or bulk packaging, *dahi* is also being sold in HDPE buckets or pots of size 1 kg, 5 kg and 10 kg.

Cheese packaging can be broadly grouped as (a) wrapping of cheese for storage and ripening and (b) retail packaging for consumers. Bulk cheeses are either paraffin wax coated or vacuum packed in flexible film. For retail consumers, blocks of cheese are cut into small random weight size, vacuum packed in barrier bags, hot water shrunk and then weighed, labeled and reassembled as a large block and put into the carton for distribution. Also, about 8-10 pieces of rectangular or triangular chiplets of cheese or processed cheese of convenient sizes (25 g) are individually wrapped with aluminum foil and placed in an outer plastic or paperboard container. Cheese spreads may also be packed in plastic tubs (usually polypropylene) and sealed with aluminum foil laminates and closed with a press on plastic lid, or plastic laminated or co-extruded squeezable tubes or bottles. Cheese is also available in slices individually wrapped in plastic films. About ten such slices are placed and sealed in an outer high barrier plastic pouch.

11.0 Packaging of traditional Indian dairy products

Traditionally the major portion of *khoa* is manufactured in the countryside, from where it is collected by middlemen in bamboo baskets lined with green leaves or used newspaper sheets fitted with loose fitting bamboo strip covers. Of late, *khoa* is being wrapped in plastic films such as PET, placed in a bamboo basket and packed using jute or hespian fiber cloth (gunny bags). A huge quantity of *khoa* contained in PE bags and tied with gunny bags is also stored for future use. Use of different packaging materials and packaging conditions resulted in different shelf lives. Hot filling of *khoa* at such a high temperature though helps in extending the shelf life, it imparts undesirable browning in *khoa* making it unsuitable for sweets making. High barrier structures or laminates based on PET-EVOH-PE are increasingly being used. Such laminates can be used for bulk packaging of *khoa* in cold stores for longer duration. Tin cans and rigid plastic containers of 15 kg capacity can also be used for bulk packaging of *khoa*.

Amongst the several *khoa*-based sweets, *burfi* and *peda* occupy most dominating place in terms of popularity and market demand. Currently, these sweets are largely prepared by sweetmeat makers

(*halwai*) on small scale and mostly packaged in paper cartons or duplex board boxes with or without butter paper lining. The traditional packages do not provide sufficient protection to these sweets from atmospheric contamination and unhygienic handling, thereby rendering them susceptible to become dry, hard and mouldy, and develop off flavours. Currently, *burfi* is packaged in HDPE or polypropylene (PP) boxes and cartons of 500g and 1 kg size with an optional inserts or cavities. *Peda* is also similarly packaged in paperboard cartons with a parchment paper liner or greaseproof paper liner. Hot filling of *burfi* in pre-sterilized polyester (PET) tubs of 250 g followed by vacuum packaging in multilayer co-extruded nylon-based pouches could extend the shelf life to 52 days at 30°C as against 16 days when packaged in ambient air. *Gulabjaman*, another important *khoa*-based sweet is largely packaged without syrup like *burfi* and *peda* in paper cartons or plastic boxes made up of HDPE or PP or PET. Although lacquered tin can is the most suitable packaging material for *gulabjaman*, it is expensive and hence, used for customers living at far-flung areas or Indian diaspora living abroad. Currently, high barrier multilayered stand-alone or gusseted pouches made from nylon and EVOH are being used for packaging of *gulabjamun*. With growing interest and commercial success of modified atmosphere packaging (MAP) technique, several Indian traditional dairy products have been successfully packaged under MAP conditions.

Commercial production of *paneer* has witnessed gradual increase in the country which has encourages development of better packaging solutions for it. Flexible packaging films like polypropylene, retort pouches (PET-Al foil-PP) and co-extruded laminates like nylon-nylon-nylon or PET-EVOH-PE or nylon-EVOH-PE or similar materials are promising materials for long-term storage of *paneer*. Flexible pouches made of high-density polyethylene bags could be used for vacuum packaging of *paneer* blocks to achieve a shelf life of about 30 days at refrigeration temperatures (6±1ºC). Vacuum packaging of *paneer* in a specially developed film (EVA/EVA/PVDC/EVA) followed by heat treatment at 90ºC for one minute could help extending the shelf life up to 90 days at refrigeration temperature. Commercially *paneer* has also been successfully packaged under MAP conditions. Several large dairy industries such as AMUL, Mother Dairy, Punjab Milkfed, Heritage, Creamline Jersey, etc. have started selling vacuum packaged *paneer*.

Since the body and texture of *rasogolla* is very delicate and it has to be preserved in sugar syrup, it is invariably packaged in lacquered tin cans of 500 g and 1 kg capacity. When the proportion of

rasogolla (10-14 pieces) and syrup is kept 40:60, and hygienic conditions are maintained during processing and handling, the product stays in good condition for about 6 months at ambient conditions, since hot filling (at about 90°C) technique is adopted. PP-Al foil laminate could be used for hot filling of syrup and *rasogolla*. High barrier multilayered stand-alone or gusseted pouches made from nylon and EVOH could alsobe used for packaging of *rasogolla*.

12.0 Packaging of condensed and dried milk products

Usual pack sizes of condensed milk for retail sale are 200 g, 400 g and 1 kg. However, 200 g and 400 g packs are popular. According to the Bureau of Indian Standards (IS: 9991, 1981), the condensed milk containers shall be round cans made from tinplate of a nominal thickness of about 0.22 mm and shall have a nominal internal diameter of about 74 mm with a gross lidded capacity of about 300 mL. The body of the can shall be single seamed, but the ends shall be double seamed. The side seam may be unsoldered, soldered, welded or cemented. When the side seam is cemented, the type of cement used shall not impart any off-flavour to the condensed milk and shall be non-toxic. Internally can surface may be plain or lacquered while externally it could be plain or printed. Bulk packaging may be done in barrels of various sizes, drums with polyethylene liners or tin containers.

For retailing to consumers, milk powder is packed into metal cans (open top sanitary (OTS) cans) with aluminum foil tagger, multilayered refill-pouches, bag-in-box type of packs or shrink sleeved glass or plastic jars. Milk powder packed in pouches is commercially available in a capacity range of 250 g to 2.5 kg. For institutional sales such as for railways and airways, the pack size could be as small as 10 g. Metal cans have been highly popular for a long time for packaging of milk powders with varying capacities (200 g, 400 g, 500 g, 1 kg, 2 kg and 2.5 kg) due to their excellent physical strength, durability, absolute barrier to moisture, oxygen and light, absence of flavour or odour and rigidity. The metal cans are usually coated with a thin layer of tin and an additional layer of organic lacquers such as epoxy-phenolic lacquer to prevent corrosion and avoid metal-powder contact. Powdered milk including infant formula may have hormonally active contaminants such as bisphenol A (BPA) introduced in the manufacturing process or leached from the lacquers of the containers. In recent times, several packaging materials (laminates and co-extruded films) have emerged as alternative to metal cans such as LDPE/nylon/LDPE, Kraft paper/aluminum foil/HDPE, LDPE/HDPE, metallized PET, PET/aluminum foil/BOPP,

PET/aluminum foil/HDPE, PET/aluminum foil/LDPE, etc. Alternatively, with pouches for which shorter shelf life is acceptable, the aluminum layer may be replaced with a high-barrier plastic layer such as copolymer of EVOH or PVdC, possibly with the addition of a thin layer of metal or silica oxide deposition to enhance its oxygen barrier characteristics. A study has reported that the shelf life of whole milk powder packaged in either PET/aluminum foil/HDPE or metallized PET (400 microns) was about 12 months. Bulk packaging of milk powders is usually done in 25 kg multiwall Kraft paper sacks or jute (hessian fabric) bags laminated with woven or non-woven plastic and having a liner made of plastic film.

References

Deshwal G.K. and Panjagari N.R. (2020). Review on metal packaging: materials, forms, food applications, safety and recyclability. *J Food Sci Technol* **57,** 2377–2392 (2020).

Deshwal G.K., Panjagari N.R. and Alam T. (2019). An overview of paper and paper based food packaging materials: health safety and environmental concerns. *J Food Sci Technol* **56,** 4391–4403.

Panjagari N.R., Singh R.R.B., Singh A.K. (2016) Indian Traditional Fermented Dairy Products. In: Kristbergsson K., Oliveira J. (eds) Traditional Foods. Integrating Food Science and Engineering Knowledge Into the Food Chain, vol 10. Springer, Boston, MA.

Raju P.N. and Singh A.K. (2016). Packaging of Fermented Milks and Dairy Products. In Puniya AK (ed) *Fermented Milks and Dairy Products*, CRC Press, Boca Raton, FL, USA. Pp: 637-672.

Sabikhi L, Khetra Y. and Raju P.N. (2018). Processing and packaging of dairy-based products. In Mohan CO, Carvajal-Millan E, Ravishankar CN and Haghi AK (eds) *Food Process Engineering and Quality Assurance*, Apple Academic Press Inc. Oakville, Canada.

*****

Concept of Laboratory Accreditation and its Implementation – Sharing Practical Experience

Rajan Sharma[1], Richa Singh[2] and Kamal Gandhi[2]
[1]Principal Scientist, [2]Scientist
Dairy Chemistry Division, ICAR-National Dairy Research Institute, Karnal

Laboratory accreditation provides formal recognition to competent laboratories, thus providing a ready means for customers to identify and select reliable testing, measurement and calibration services. To maintain this recognition, laboratories are re-evaluated periodically by the accreditation body to ensure their continued compliance with requirements, and to check that their standard of operation is being maintained. The laboratory may also be required to participate in relevant proficiency testing programs between reassessments, as a further demonstration of technical competence.

Accredited laboratories usually issue test or calibration reports bearing the accreditation body's logo or endorsement, as an indication of their accreditation. Clients are encouraged to check with the laboratory as to what specific tests or measurements they are accredited for, and for what ranges or uncertainties. This information is usually specified in the laboratory's scope of accreditation, issued by the accreditation body. The description in the scope of accreditation also has advantages for the customers of laboratories in enabling them to find the appropriate laboratory or testing service.

Laboratory accreditation uses criteria and procedures specifically developed to determine technical competence. Specialist technical assessors conduct a thorough evaluation of all factors in a laboratory that affect the production of test or calibration data. The criteria are based on an international standard called ISO/IEC 17025:2017, which is used for evaluating laboratories throughout the world. Laboratory accreditation bodies use this standard specifically to assess factors relevant to a laboratory's ability to produce precise, accurate test and calibration data, including the:

- technical competency of staff
- validity and appropriateness of test methods
- traceability of measurements and calibrations to national standards

- suitability, calibration and maintenance of test equipment
- testing environment
- sampling, handling and transportation of test items
- quality assurance of test and calibration data

Manufacturing organizations may also use laboratory accreditation to ensure the testing of their products by their own in-house laboratories is being done correctly.

A marketing advantage: Laboratory accreditation is highly regarded both nationally and internationally as a reliable indicator of technical competence. Many industries, such as the construction materials industry, routinely specify laboratory accreditation for suppliers of testing services. Unlike certification to ISO 9001, laboratory accreditation uses criteria and procedures specifically developed to determine technical competence, thus assuring customers that the test, calibration or measurement data supplied by the laboratory or inspection service are accurate and reliable.

A benchmark for performance: Laboratory accreditation benefits laboratories by allowing them to determine whether they are performing their work correctly and to appropriate standards, and provides them with a benchmark for maintaining that competence. Many such laboratories operate in isolation to their peers, and rarely, if ever, receive any independent technical evaluation as a measure of their performance. A regular assessment by an accreditation body checks all aspects of a facility's operations related to consistently producing accurate and dependable data. Areas for improvement are identified and discussed, and a detailed report provided at the end of each visit.

International recognition for your laboratory: Many countries around the world have one or more organizations responsible for the accreditation of their nation's laboratories. Most of these accreditation bodies have now adopted ISO/IEC 17025 as the basis for accrediting their country's testing and calibration laboratories. This has helped countries employ a uniform approach to determining laboratory competence. It has also encouraged laboratories to adopt internationally accepted testing and measurement practices, where possible. This uniform approach allows countries to establish agreements among themselves, based on mutual evaluation and acceptance of each other's accreditation systems. Such international agreements, called mutual recognition

arrangements (MRAs), are crucial in enabling test and calibration data to be accepted between these countries. In effect, each partner in such an MRA recognizes the other partner's accredited laboratories as if they themselves had undertaken the accreditation of the other partner's laboratories. ILAC (International Laboratory Accreditation Co-operation) is the peak international authority on laboratory accreditation, with a membership consisting of accreditation bodies and affiliated organizations throughout the world. In conjunction with ILAC, specific regions have also established their own accreditation co-operations, notably in Europe (EAL) and the Asia-Pacific (APLAC). These regional co-operations work in harmony with ILAC and are represented on ILAC's board of management. India is also a signatory to ILAC Arrangements as well as APLAC MRAs.

How does using an accredited laboratory benefit government and regulators?

Government bodies and regulators must have confidence in the data generated by laboratories in order to make these decisions. Using an accredited laboratory can help establish and assure this confidence. If a laboratory is accredited, it means that the laboratory has achieved a prescribed level of technical competence to perform specific types of testing, measurement and calibration activities. The result is assurance that the laboratory is capable of producing data that are accurate, traceable and reproducible – critical components in governmental decision-making.

Using an accredited laboratory benefits government and regulators by:

- Increasing confidence in data that are used to establish baselines for key analyses and decisions
- Reducing uncertainties associated with decisions that affect the protection of human health and the environment
- Increasing public confidence, because accreditation is a recognizable mark of approval
- Eliminating redundant reviews and improving the efficiency of the assessment process (which may reduce costs)
- Purchases received from suppliers are safe and reliable
- Costs associated with laboratory problems, including re-testing, resampling, and lost time are minimized
- False positives and negatives, which can directly affect compliance with regulations, are minimized

Using accredited laboratories also facilitates trade and economic growth because data generated by an accredited laboratory may lead to the more ready acceptance of exported goods in overseas markets. This reduces costs and eases exports and imports, as it reduces or eliminates the need for retesting in another country.

What types of laboratories can seek accreditation?

Most national accreditation bodies can provide comprehensive accreditation for: facilities undertaking any sort of testing, product or material evaluation, calibration or measurement; private or government laboratories; one-person operations or large multi-disciplinary organizations; remote field operations and temporary laboratories.

Accreditation of Food Laboratories

A food laboratory may be accredited for the following classes of tests:

- Food Products – Chemical Testing
- Food Products – Microbiological Testing
- Food Products – Micronutrients
- Food Products – Residues
- Food Products – Sensory Evaluation
- Microbiological Condition of Food Processing Factories
- Packaging tests
- Shelf Life testing

Laboratories seeking accreditation for chemical, microbiological and sensory food analyses must be able to demonstrate that they can competently use the methods included in the scope of the accreditation. If a method is to be used for the official control of foods there are extensive requirements on internal verification, *i.e.* that the laboratory is able to demonstrate that it can use the method in a way, which enables the analytical task to be solved. The following requirements are examples of factors which laboratories seeking accreditation should pay attention to, since they often are included in a competence assessment:

- the laboratory must have information on the method: is it based on a standard or reference method, or has it been internally developed?

- any deviation in a method as compared to a reference method is fully described and the effects of the deviation have been investigated;
- the method has been verified, *e.g.* by analysing spiked samples of relevant matrices;
- the laboratory's own written method text is available;
- the method has been in use in the laboratory for a time period of a minimum of three months during which a number of 'real' samples of relevant types have been analyzed;
- quality control procedures are in place, *e.g.* analysis of reference or control materials, or control strains;
- if possible, the laboratory participates in proficiency testing schemes and evaluates, on a continuous basis, the results;
- where relevant, the measurement uncertainty has been estimated and
- if a sensory laboratory, it monitors the performance of individual sensory assessors and of panels.

Documentation showing that the laboratory complies with the requirements presented above must normally be available to the accreditation body and their technical assessors three to four weeks before the assessment. This information is a useful tool for the assessors when they select which parts of an analytical chain are to be assessed. The evaluation of a laboratory's results on the basis of the elements listed above is carried out in order to assess the analytical activities and capabilities of a laboratory to obtain an overall impression of the laboratory. The result should demonstrate whether the laboratory is competent and proficient in the use of the methods for which accreditation is sought.

The standardization and accreditation of sensory quality evaluation methods is a pressing need for the certification of food products, particularly for foods and beverages with specific sensory characteristics, such as those with a protected designation of origin. A training and qualification process for expert panelists is required. In cheese, panelists score quality of overall sensory parameters (shape, rind, paste colour, eyes, odour, texture, flavour and aftertaste) on a scale, based on how close the product lies to a specific quality standard. Panelists justify the quality scores given on the basis of the absence/presence of specific characteristics in the product and/or the presence of defects. Training requires the prior establishment of references for both characteristics

and defects. Qualification trials determine whether or not the expert panelists (both individually and as a panel) are appropriately qualified to carry out the sensory evaluation. This work also shows the quality control maintenance of qualifications for the expert panelist. This approach could be generalized to any type of food and beverage as a reference for the accreditation of sensory quality evaluation methods according to ISO 17025. In this way, each product manufacturer would be able to define its quality standard and, on the basis of this standard, carry out the sensory evaluation using a panel specifically trained for this purpose.

Laboratory accreditation in India

National Accreditation Board for Testing and Calibration Laboratories (NABL), a Constituent Board of Quality Council of India has been established with the objective of providing Government, Industry Associations and Industry in general with a scheme of Conformity Assessment Body's accreditation which involves third-party assessment of the technical competence of testing including medical and calibration laboratories, proficiency testing providers and reference material producers. In the year 2016, in pursuance of cabinet decision (February 1996), NABL along with the support mechanism existing under the Department of Science and Technology, Ministry of Science and Technology was transferred to the Department of Industrial Policy and Promotion (DIPP), Ministry of Commerce and Industry and subsequently transferred to QCI (Quality Council of India) as one of its Board. In the year 2017, NABL society regn. No. S/33451 has been merged with QCI society.

NABL provides accreditation to:

- ✓ Testing laboratories as per ISO/IEC 17025
- ✓ Calibration laboratories as per ISO/IEC 17025
- ✓ Medical testing laboratories as per ISO 15189
- ✓ Proficiency Testing Providers (PTP) as per ISO/IEC 17043
- ✓ Reference Material Producers (RMP) as per ISO 17034

NABL maintains linkages with the international bodies like International Laboratory Accreditation Co-operation (ILAC) and Asia Pacific Accreditation Co-operation (APAC). NABL is a full member and a signatory to International Laboratory Accreditation Cooperation (ILAC) since 2000 (Testing ISO/IEC 17025- 2 November 2000, Calibration ISO/IEC 17025- 2 November 2000,

Medical Testing ISO 15189- 2 November 2000, Proficiency Testing providers ISO/IEC 17043- 3 October 2019 and Reference Material Producers ISO 17034-22 July 2020) as well as Asia Pacific Accreditation Cooperation (APAC) Mutual Recognition Arrangements (MRA), which is based on peer evaluation. Such international arrangements facilitate acceptance of test/ calibration results between countries which MRA partners represent.

NABL is a full member (MRA signatory) to International Laboratory Accreditation Co-operation (ILAC) as well as Asia Pacific Laboratory Accreditation Co-operation (APLAC) since 2000 on the basis of peer evaluation by APLAC as per ISO/IEC 17011:2004Government of India has authorized National Accreditation Board for Testing and Calibration Laboratories (NABL) as the accreditation body for Testing and Calibration laboratories.

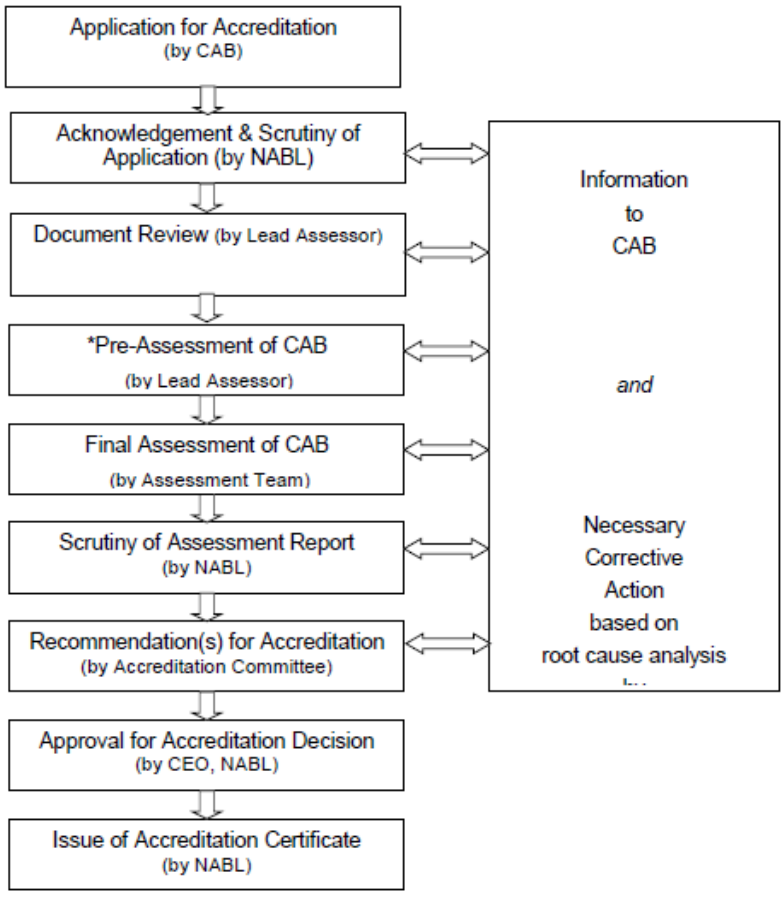


Figure 1. NABL Accreditation Process

Accreditation process adopted by NABL is indicated in Figure 1. In NABL parlance, the term CAB (Confirmatory Assessment Body) is used for the laboratory seeking accreditation. The accredited CAB is subjected to re-assessment every 2 years. The CAB has to apply 6 months before the expiry of accreditation to allow NABL to organize assessment of the CAB, so that the continuity of the accreditation status is maintained. Application submitted after expiry are not considered for renewal of accreditation. In such a case, the CAB has to apply afresh.

NABL allows integrated assessment which a unified approach to have a common assessment of laboratories for NABL & Regulatory Body (ies) such as Export Inspection Council (EIC), Agricultural and Processed Food Products Export Development Authority (APEDA), Indian Oilseeds and Produce Export Promotion Council (IOPEPC), other commodity board (s) under the ambit of Department of Commerce, Govt. of India and Food Safety & Standards Authority of India (FSSAI) under Ministry of Health & Family Welfare, Govt. of India. This integrated approach will ease laboratories in getting accredited by NABL in conjunction with the recognition/ approval by the concerned Regulatory Body (ies) through a single assessment/ application.

Conclusion

Laboratory accreditation has an important role to play in establishing the credibility of laboratories. Customers of the providers of analytical data need to be assured about the quality of the data that is being given to them. Experience in many laboratory studies at national and international level in the past has demonstrated that besides standardized and validated methods (although these are key factors); analytical quality assurance plays a key role for the reliability of laboratory results. Introduction of systematic quality assurance procedures of the analytical work itself is now expected to become a requirement for confidence in laboratories and for the acceptance of the results. In this regard laboratory accreditations play an important role in establishing the credibility of analytical laboratories.

*****

Food Quality and Safety Management Practices Relevant to Dairy Industry

Raghu H.V.
Scientist (Senior Scale), National Referral Centre for Milk Quality and Safety
Dairy Microbiology Division, ICAR-National Dairy Research Institute, Karnal

Introduction

India has a rich cultural heritage and the people believe in consuming home-made foods. Such foods are considered more nutritious and safer compared to processed foods as currently consumed in the western world. The food which we eat everyday like milk is a nutritious food has tremendous impact on our physical, mental and spiritual health. It allows the growth of microorganisms due to its composition includes proteins, fats, carbohydrates, vitamins, minerals, and essential amino acids, which provide an adequate environment for the microorganisms' proliferation because of a neutral pH and a high-water activity on milk. Some microorganisms use these nutrients directly, and others unleash the metabolism of them. Further, food consumption pattern, ever increasing demands on quality and safety are under continuous transformation and need critical appraisal to overview and timely adoption of corrective and preventive action in food supply chain. Consumer's preference of processed food with new requirements especially minimally processed/ cost effective foods without chemical preservatives with enhanced functional and therapeutic features has put up pressure on manufacturer to adopt all ways and means to ensure quality and safe food to the consumers. These consumer demands are forcing the manufacturer to implement new quality (QMS) and food safety system (HACCP) and practices (GMP, GHP, etc.) during various stages of supply chain from milch animal to consumer. Therefore, in this present project we are going to discuss about different food quality and safety system and practices followed in dairy sector from farm up to consumer level.

Quality Control and Quality Assurance Concepts

Quality is defined by the International Organization for Standardization (ISO) as ―the totality of features and characteristics of a product that bear on its ability to satisfy stated or implied needs/ or the operational techniques and activities that are used to satisfy quality requirements. A food industry quality management system is an integrated set of documented food quality and food safety activities with clearly established inter relationships among the various activities. The

objective of a quality system is to provide a food company with the capability to produce a food that fulfils all quality and safety requirements (Fig.1).

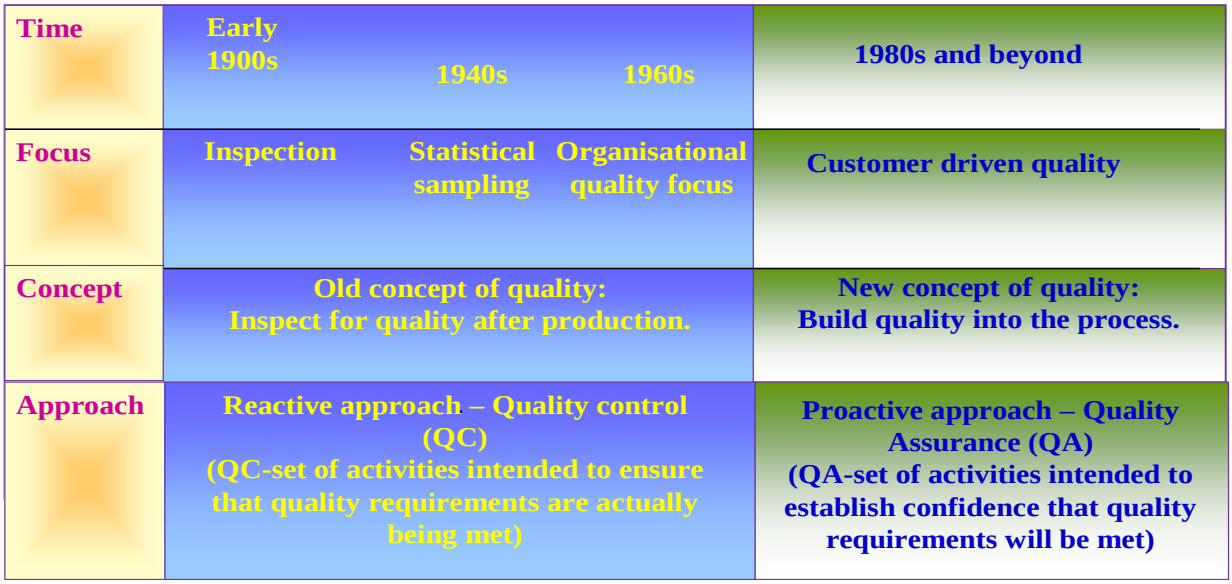


Fig. 1 Quality assurance concept in relation to changes in global food safety standards

Food supply chain concept

With the rising liberalization of agro-industrial markets and thus the world-wide integration of food supply chains, the assurance of food quality and safety has become a major concern. Following serious and repeated incidents such as mad cow disease (Bovine Spongiform Encephalitis–BSE), Dioxin, Aflatoxin and most recently, Sudan Red consumer protection has become a priority in policy making in the large consumer markets. The recent occurrence of serious food scares and food contamination events – such as *Salmonella* contagion of peanut butter in the US, melamine contamination of milk in China and high pesticide content of aerated drinks manufactured in India – has significantly enhanced the concern for food safety and its impact on health, marketing and foreign trade. Protecting consumer health from food borne hazards has become a compelling duty for policy makers across the globe. Consequently, regulatory frameworks and standards are being developed wherein trade and health issues are being addressed by prioritizing consumer protection over freedom of trade. Thus, it has become imperative for the Indian industry and policy makers to adopt strong practices of food safety so as to remain sustainably competitive both in domestic and export markets. In this context, it is essential to have a close look at the recent changes in food safety regulations adopted in India which if effectively

implemented will not only protect domestic consumers from food contamination hazards, but also become instrumental in making India meet international standards of food safety.

Hence, legal requirements for quality assurance systems and food control along the entire food chain, from seed and agricultural production, through food processing and the distribution system, up to the consumers' table, are increasing considerably. Major prerequisite for ensuring food quality and safety is that all stakeholders in the food supply chain recognize that primary responsibility lies with those who produce, process and trade food and that public control should be based on scientific risk assessment (Fig. 2).

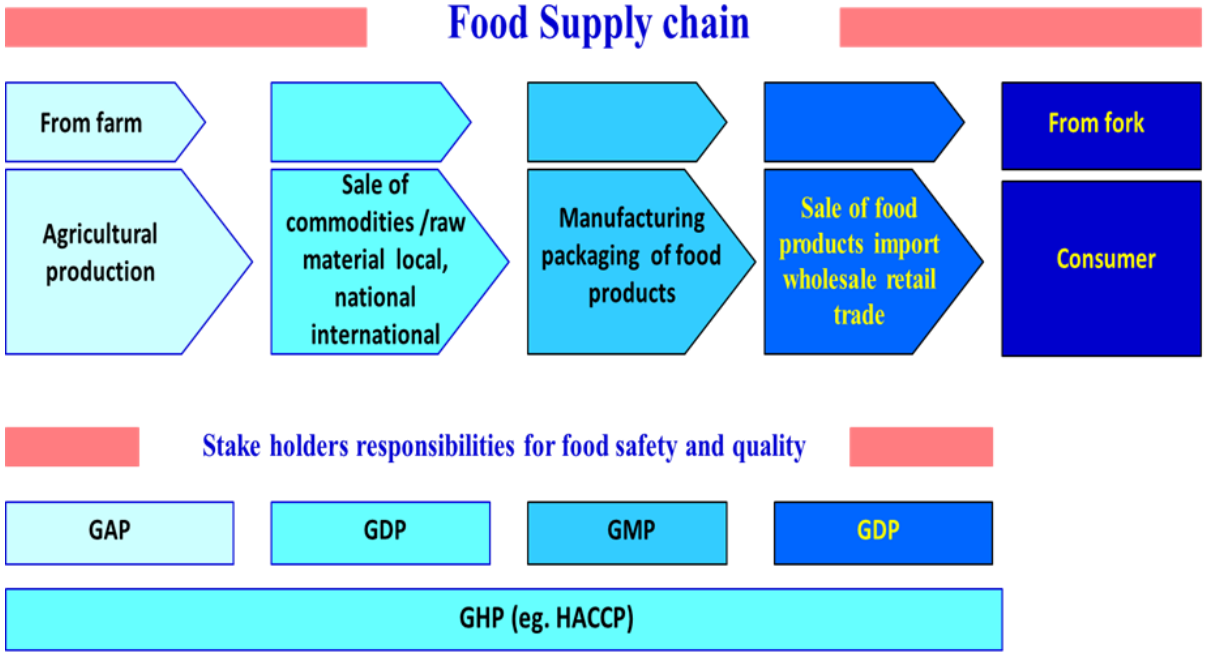


Fig. 2 Food Supply Chain and operators' responsibility for food quality and safety

GAP = Good Agricultural Practices; **GDP** = Good Distribution Practices; **GMP** = Good Manufacturing Practices; **GHP** = Good Hygienic Practices

Operators' responsibilities cover the whole food supply and marketing chain from primary production to final consumption and encompass all actors in exporting and importing countries. Public and private standards are subject to continuous changes as a result of on-going process of liberalization of the world trade to establish cost-effective supplier-buyer linkages and to gain a competitive edge. Globalization of the food supply chain, the increasing importance of the Codex Alimentarius Commission and the obligations emerging from the World Trade Organization

(WTO) Agreements have resulted in unprecedented interest in the development of food standards and regulations and the strengthening of food control infrastructure at the country level.

Management Systems for Quality and Food Safety

Excellence in food quality and safety has taken a tangible form with the advent of ISO 9000 Quality Management System and HACCP standards. ISO 9000 encompasses all the activities of a company to ensure that it meets its quality objectives, while HACCP is directed towards ensuring food safety. The ISO 9000 standards were brought by the International Organization for Standardization (ISO) and the HACCP standards by the CAC. These standards have assumed importance worldwide both as an essential requirement to tap the market potential and as a marketable feature of the company. Since the global market has become more demanding in terms of quality, safety and timely delivery, installation of the ISO 9000 Quality Management System and HACCP by the food industry is essential for getting a competitive international edge. Food Safety Programs may need to be implemented to meet regulatory requirements, retailer requirements or manufacturer's requirements.

ISO 9000 Quality Management Systems: The ISO 9000 system is looked at as a system with minimum quality requirements. It builds a baseline system for managing quality. The focus, therefore, is on designing a total quality management system, one that complies with external standards, but includes the specific requirement of industry and integrates elements of competitiveness.

Food safety management system

ISO 22000, Food safety management systems – Requirements for any organization in the food chain, was first published in 2005. The standard provides international harmonization in the field of food safety standards, offering a tool to implement HACCP (Hazard Analysis and Critical Control Point) throughout the food supply chain. The process module of ISO 22000:2005 has been shown in Fig. 3.

The goal of ISO 22000 is to control and reduce to an acceptable level, any safety hazards identified for the end products delivered to the next step of the food chain. An end product is defined as a product that will not undergo any further processing or transformation by the organization. The

standard combines the following generally-recognized key elements to ensure food safety at all points of the food chain:

- Requirements for good manufacturing practices or prerequisite programs
- Requirements for HACCP according to the principles of the Codex Alimentarius (an international commission established to develop food safety standards and guidelines)
- Requirements for a management system
- Interactive communication between suppliers, customers and regulatory authorities.

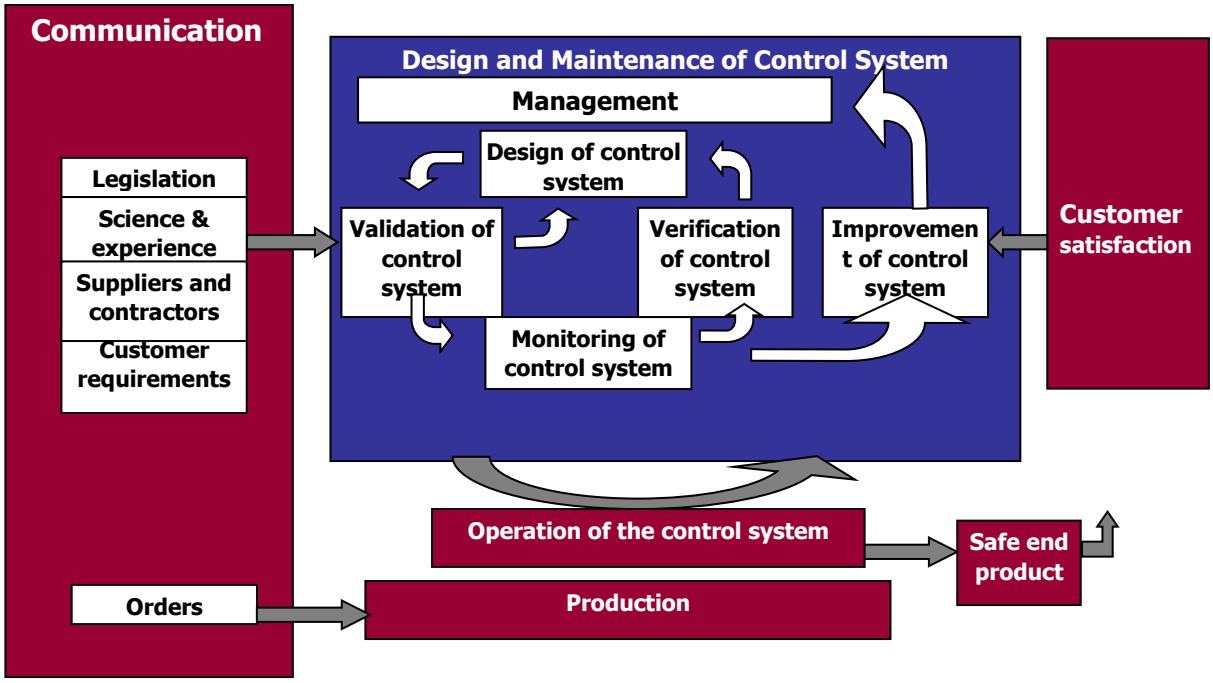


Fig. 3 Process module of the standard ISO 22000:2005

ISO 22000:2005 specifies requirements for a food safety management system where an organization in the food chain needs to demonstrate its ability to control food safety hazards in order to ensure that food is safe at the time of human consumption. It is applicable to all organizations, regardless of size, which are involved in any aspect of the food chain and want to implement systems that consistently provide safe products. The means of meeting any requirements of ISO 22000:2005 can be accomplished through the use of internal and/or external resources.

Pre-requisite programmes

Before implementation of HACCP in dairy industry, some basic conditions or practices are

necessary for the manufacture of quality and safe food to the consumers those practices are known as pre-requisite programmes (PRPs). Some examples of common PRPs are Good Manufacturing Practices (GMPs), Good hygiene practices (GHPs) and the Sanitation Standard Operating Procedures (SSOPs), and pest control. Regular maintenance of these PRPs are very imperative to the accomplishment of the HACCP plan and functioning effectively (Bernard et al., 1997). Understanding the difference between HACCP and prerequisite programs is accomplished through the recognition of two main points. First, prerequisite programs deal indirectly with food safety, whereas, HACCP focuses solely on food safety. Second, prerequisites tend to be more general and applicable across a processing plant. HACCP plans are only based on hazard analyses that are product or line specific.

Good Manufacturing practices

Good Manufacturing Practices (GMP) is a system that ensures that the goods produced by various manufacturing facilities are consistently produced and controlled according to specified quality standards. Good Manufacturing Practices are a critical system that all manufacturing facilities should implement. They help ensure the proper design, monitoring, and control of the manufacturing processes and facilities. Companies that adhere to these standards help to assure the identity, strength, and quality of their products. When implemented, GMP can help to cut down on facility losses and waste and also help to protect the company, consumer, and the environment from harm. Good Manufacturing Practices in food industry manufacturers are especially vital these days, due to the increasing number of food recalls occurring. Consumers have become increasingly aware of food safety and expect companies to take steps to increase their accountability, and provide them with safe products that will not get recalled. The Standard specifies the requirements for location of dairy product factories and plant environment, plant and workshop, equipment, hygiene management, raw materials and packing materials and the requirements for food safety control in production, product testing, product storage and transportation, record and document management, product follow-up and call-back, management organization and personnel.

Good Hygiene Practices

Good Hygiene Practices (GHPs) are practices regarding the conditions and measures necessary to ensure the safety and suit-ability of food at all stages of the food chain. Good Hygiene Practices

aim to implement the essential principles of food hygiene applicable throughout the food chain (including primary production through to the final consumer), to achieve the goal of ensuring that food is safe and suitable for human consumption. Good hygiene practices in food establishments are essential for consumer protection and the control of public health risks. This is because, the hygiene of food workers can contribute significantly to outbreak and transmission of foodborne illnesses. The various stages in the milk processing chain, from milking the cow to consumption, must be properly controlled to assure the quality and safety of milk and dairy products. Adherence to basic good hygiene practices is one of the first steps to achieve quality and safe food to the consumers. The implementation of good hygienic practices (GHP) is required to control the food quality and to ensure that the customers are not exposed to any food-related risks. These practices consist of a set of procedures aimed to attain specific identity and quality standards of products and/or services in the food industry, including materials and utensils these products may get in contact with it.

HACCP system

HACCP stands for Hazard Analysis Critical Control Point. HACCP is a systematic approach to the identification, evaluation, and control of food safety hazards. It is a proactive strategy where hazards are identified and assessed, and control measures are developed to prevent, reduce, or eliminate a hazard. The HACCP system, which is science based and systematic, identifies specific hazards and measures for their control to ensure the safety of food. HACCP is a tool to assess hazards and establish control systems that focus on prevention rather than relying mainly on end-product testing. Any HACCP system is capable of accommodating change, such as advances in equipment design, processing procedures or technological developments. HACCP can be applied throughout the food chain from primary production to final consumption and its implementation should be guided by scientific evidence of risks to human health. As well as enhancing food safety, implementation of HACCP can provide other significant benefits. In addition, the application of HACCP systems can aid inspection by regulatory authorities and promote international trade by increasing confidence in food safety. The successful application of HACCP requires the full commitment and involvement of management and the work force. It also requires a multidisciplinary approach; this multidisciplinary approach should include, when appropriate, expertise in agronomy, veterinary health, production, microbiology, medicine, public health, food

technology, environmental health, chemistry and engineering, according to the particular study. The application of HACCP is compatible with the implementation of quality management systems, such as the ISO 9000 series, and is the system of choice in the management of food safety within such systems.

Good Laboratory Practices

GLP embodies a set of principles that provides a framework within which laboratory studies are planned performed, monitored, reported and archived. GLP is sometimes confused with the standards of laboratory safety like wearing safety goggles. According to OECD, GLP is defined as 'a quality system concerned with the organizational process and the conditions under which non-clinical health and environmental studies are planned, performed, monitored, recorded, archived and reported.' It is applicable in all aspects of a laboratory including; implementing, validating and maintaining the laboratory compliance. GLP is used for Generating reproducible, accurate analytical results is important for laboratory success, but isn't necessarily easy to do. However, there are processes and tools that are critical components of successful laboratory quality assurance programs. In general many of the practices that lead to a successful quality assurance program are also required for general business success such as: good communication, engaged employees and management, a strong training program and a facility that supports the work to be done in the lab.

Suggested References

Te Giffel, M. C., and M. H. J. Wells-Bennik. "Good hygienic practice in milk production and processing." In *Improving the Safety and Quality of Milk*, pp. 179-193. Woodhead Publishing, 2010.

Ruegg, P. L. (2003). Practical food safety interventions for dairy production. *Journal of dairy science*, *86*, E1-E9.

Perin, L. M., Pereira, J. G., Bersot, L. S., & Nero, L. A. (2019). The Microbiology of Raw Milk. In *Raw Milk* (pp. 45-64). Academic Press.

Lemma D, H., Mengistu, A., Kuma, T., & Kuma, B. (2018). Improving milk safety at farm-level in an intensive dairy production system: relevance to smallholder dairy producers. *Food Quality and Safety*, *2*(3), 135-143.

Frolova, O. N. (2017). THE ORGANIZATION OF THE SYSTEM OF QUALITY MANAGEMENT ON THE PRINCIPLES OF HACCP IN DAIRY FARMING. *Vestnik of Samara University. Economics and Management*, (4), 73-77.

Sharma, D., Anandamram, K. S., & Aeri, V. A Global Perspective of HACCP Implementation in Dairy Industry.

*****

Food Package Labelling Requirements

Narender Raju Panjagari

Scientist (Senior Scale), Food Packaging Laboratory
Dairy Technology Division, ICAR-National Dairy Research Institute, Karnal

A label is a piece of material affixed to a container or product on which is written or printed information about the product. Labels have many uses including providing information on a product's origin, use, shelf life and mode of disposal, etc., some or all may be governed by the law of land (legislation). Food package labelling is any written, electronic or graphic communication on the package of a food product or on a separate label, but are integral part of the package. These may carry price, directions for use, addresses of manufacturer, brand, bar code, etc.

3.0 General Requirements

In India, the food package labelling is governed by the Food Safety and Standards (Labelling and Display) Regulations (2020) which has recently replaced the previous Food Safety and Standards (Packaging and Labelling) Regulations (2011). The general requirements are as follows:

a) Every pre-packaged food shall carry a label.
b) When a food product is sold through e-commerce or any other direct selling means, the mandatory requirements of the label as given in the regulations shall be provided to the consumer through appropriate means before sale except batch number/lot number, best before, use-by-date, expiry date, date of manufacturing / packing.
c) Pre-packaged food shall not be described or presented on any label or in any labelling in a manner that is false, misleading or deceptive or is likely to create an erroneous impression regarding its character in any respect.
d) Ay information or pictorial device written, printed or graphic matter may be displayed on the label provided that it is not in conflict with the requirements of the regulations.
e) The particulars of declaration required under these regulations are to be specified on the label either in English or Hindi in Devnagri script. However, nothing prevents the use of any other language in addition to English or Hindi.
f) The label on the pre-packaged foods shall be applied in such a manner that they will not become separated from the container.

g) The contents on the label shall be clear, prominent, indelible (cannot be removed) and readily legible by the consumer under normal conditions of purchase and use.

h) Where a package is provided with an outside container or wrapper and such container or wrapper is displayed for retail sale, it shall also contain all the declarations which are required to appear on the package except where such container or wrapper itself is transparent and the declarations on the package(s) are easily readable through such outside container or wrapper.

2.0 Labelling Requirements

In addition to the general labelling requirements mentioned above, every package of food shall carry the pre-packaged food product information on the label. The details are as follows:

a) **The name of the food**: The name of the food shall carry name of the food which indicate the true nature of the food contained in the package, on the front of the pack: where a food is specified by certain essential composition under FSSR made under the Act, that establishes its identity the name provided therein shall be used; in the absence of such name, either a common or usual name or an accompanying description of true nature of food shall be used; it may additionally have a "coined", "fanciful", "brand" or "trade name" subject to compliance of Food Safety and Standards (Advertising and Claims) Regulation (2018).

b) **List of ingredients**: Except for single ingredient food, a list of ingredients shall be declared on the label. Declaration of the list of ingredients shall contain an appropriate term or title such as "Ingredients". Further, the names of the ingredients shall be listed in descending order of their composition by weight or volume, as may be the case, at the time of its manufacture. Also, a specific name shall be used for ingredients in the list of ingredients that fall into a particular class e.g. all types of cheese under "*Cheese*"; cocoa bean, cocoa nib, cocoa mass, cocoa powder under "*Cocoa solids*". If the ingredient itself is the product of two or more ingredients, such a compound ingredients shall be declared in the list of ingredients and shall be accompanied by a list, in brackets, of its ingredients in descending order of weight or volume. If water is added as an ingredient it shall be declared in the list except in cases where it forms a part of an ingredient such as brine, syrup or both. In case of dehydrated or condensed foods, which are intended to be reconstituted by addition of

water, the ingredients in such reconstituted food shall be declared in descending order of weight or volume as the case may be and shall contain a statement such as "*Ingredients of the product when prepared in accordance with the directions on the label*".

c) **Nutritional Information**: Every pre-packaged food label shall contain nutritional information or nutritional facts per 100 g or 100 mL or per serving of the product as per the following:

- Energy value shall be in "kcal"
- The amounts of protein, carbohydrate (with quantity of cane sugar specified) and fat in "g" or "mL".
- The amount of any other nutrient for which a nutrition or health claim is made. If the claim is made regarding the amount or type of fatty acids or the amount of cholesterol, the amount of saturated fatty acids, monounsaturated fatty acids and polyunsaturated fatty acids in gram (g) and cholesterol in milligram (mg) shall be declared. Further, the amount of *trans* fatty acid content in gram (g) shall be declared. A health claim of "*trans fat free*" may be made where the *trans* fat is less than 0.2 g per serving of food and the claim "*saturated fat free*" may be made in cases where the saturated fat does not exceed 0.1 g per 100 g or 100 mL of food.
- The information on vitamins and minerals shall be expressed in metric units.
- Where the nutritional information is made per serving, the amount in gram (g) or millilitre (mL) shall be declared.
- The following foods are exempted from mandatory nutritional labelling: (a) unprocessed products that comprise a single ingredient; (b) processed products in which the only processing they have been subjected to is maturing and that comprise a single ingredient; (c) waters intent for human consumption, including those where the only added ingredients are CO_2; (d) a herb, a spice or mixtures thereof (masalas) meant for direct consumption; I salt and salt substitute; (f) table top sweeteners; (g) coffee extracts and chicory extracts, whole or milled coffee beans and whole and milled decaffeinated coffee, soluble coffee powder, coffee-chicory mixture; (h) herbal and fruit infusions, tea, decaffeinated tea, instant or soluble tea or tea extract; (i) fermented vinegars and substitutes for vinegar; (j) flavourings, food additives, processing aids, food enzymes, gelatine, yeast; (k)

chewing-gums; (l) alcoholic beverages; and (m) Foods for Special Dietary Uses (FSDU), Foods for Special Medical Purposes (FSMP) subject to compliance of requirements specified in the Food Safety and Standards (HS, N, FSDU, FSMP, FF and NF) Regulations (2016).

d) **Declaration regarding veg or non-veg**: Every package of "non-vegetarian" food shall bear a declaration to this effect on the principal display panel made by a symbol and colour code as shown below (Fig.1) to indicate that the product is non-vegetarian food. The symbol shall consist of a brown colour filled **triangle** inside a square with brown outline, having the sides not less than the minimum size specified. Where any article of food contains egg only as non-vegetarian ingredient, the manufacturer, packer or seller may give declaration to this effect in addition to the above said symbol. Every package of "vegetarian" food shall also bear a declaration to this effect by a symbol and colour code. The symbol shall consist of a green colour filled circle, having a diameter not less than the minimum size specified, inside the square with green outline, length of each side being double the diameter of the circle (Table-1).

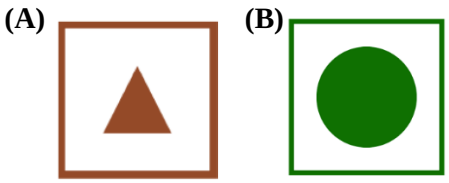


Fig. 1 An illustration of (A) "non-veg" and (B) "veg" logos on a packaged food label

Table-1. Size of the Veg or Non-Vege Food Logo as per FSS (L&D) Regulations (2020)

Area of the principal display panel	Minimum size of diameter of circle (in mm)	Minimum size of each side of Triangle (in mm)	Minimum size of each side of square (in mm)
Up to 100 cm^2	3	2.5	6
Above 100 cm^2 upto 500 cm^2	4	3.5	8
Above 500 cm^2 upto 2500 cm^2	6	5	12
Above 2500 cm^2	8	7	16

Principal display panel is the part of the package or container which is intended or likely to be displayed or presented or shown or examined by the customer under normal selling

conditions. Further, the symbol shall be prominently displayed on the package having contrast background on the principal display panel, just close to the name or brand of the product and also on the labels, containers, pamphlets, leaflets, advertisements, brochures, etc.

e) **Declaration regarding food additives**: All the food additives that have been used in the manufacture of a packaged food product shall be declared on the label as specified in Food Safety and Standards (Food Product Standards and Food Additives) Regulations (2011). For food additives falling in the respective classes and appearing in lists of food additives generally permitted for use in foods, the title class given in Table-2 below shall be used together with the specific names or recognized international numerical identifications (INS numbers).

Table-2 List of food classes listed under permitted food additives

Food Class	Example	Identification Number
Acidity regulator	Citric acid	INS 330
Anticaking agent	Calcium carbonate	INS 170
Antifoaming agent	Methylphenylpolysiloxane	INS 900 b
Antioxidant	Ascorbic acid	INS 300
Bulking agent	Polydextroses A and N	INS 1200
Colour	Sunset Yellow FCF	INS 110
Colour retention agent	Ferrous gluconate	INS 579
Emulsifier	Sorbitan monostearate	INS 491
Emulsifying salt	Trisodium citrate	INS 331 (ii)
Firming agent	Qulillaia extracts	INS 999
Flour treatment agent	Potassium bromate	INS 924 a
Flavour enhancer	Monosodium glutamate	INS 621
Gelling agent	Carrageenan and its salts	INS 407
Glazing agent	Shellac	INS 904
Humectant	Sorbitol and sorbitol syrup	INS 420
Preservative	Sodium benzoate	INS 211
Propellant	Propane	INS 944
Raising agent	Sodium hydrogen carbonate	INS 500 (ii)
Stabilizer	Sodim alginate	INS 401
Sweetener	Sucralose	INS 955

Where extraneously colouring matter has been added, it has to be mentioned with one of the following statements in capital letters, just beneath the list of ingredients on the label of the pack.

CONTAINS PERMITTED NATURAL COLOUR(S)

OR

CONTAINS PERMITTED SYNTHETIC FOOD COLOUR(S)

OR

CONTAINS PERMITTED NATURAL AND SYNTHETIC FOOD COLOUR(S)

Where extraneously flavouring agent has been added, it has to be mentioned with one of the following statements in capital letters, just beneath the list of ingredients on the label of the pack.

CONTAINS ADDED FLAVOUR

If both colour and flavour are used in the product, one of the following combined statements in capital letters shall be displayed, just beneath the list of ingredients on the label of the pack.

CONTAINS PERMITTED NATURAL COLOUR(S) AND ADDED FLAVOUR(S)

OR

CONTAINS PERMITTED SYNTHETIC FOOD COLOUR(S)
AND ADDED FLAVOUR(S)

OR

CONTAINS PERMITTED NATURAL AND SYNTHETIC FOOD COLOUR(S)

f) **Name and complete address of the manufacturer**: The name and complete address of the manufacturer and the manufacturing unit if these are located at different places and in case of the manufacturer is not the packer or bottler, the name and complete address of the packing or bottling unit shall be declared on every package of food. If a product is manufactured or packed or bottled by a person or company under the written authority of some other manufacturer, the name and complete address of the manufacturer, for and on

whose behalf it is manufactured, are to be mentioned. Further, if the food is imported into India, the package of food shall also carry the name and address of the importer in India.

g) **FSSAI Logo and License Number**: The FSSAI logo and license number under the Act shall be displayed on the label of the food package in contrast colour to the background as given below:

Lic. No. XXXXXXXXXXXXX

The FSSAI logo and license number of the brand owner shall be displayed on the label. IN addition, the license number of manufacturer or marketer or packer or bottler, as the case may be, if different from the brand owner, shall be displayed on the label. In case of imported food products, the importer shall display FSSAI logo and license number along with name and address of the importer. Further, fortified food and organic food shall be marked with logo as specified in the regulations (given below).

Fortified with....
SAMPOORNA POSHAN
SWASTHA JEEVAN

h) **Net quantity, Retail Sale Price and Consumer Care Details**: Every package label shall carry the net weight or volume or number of the product, as the case may be. In addition to the declaration of net quantity, a food packed in a liquid medium shall carry a declaration of the drained weight of the food. Liquid medium includes water, aqueous solutions of sugar and salt, fruit and vegetable juices or vinegar, either singly or in combination. Further, the declarations shall be as provided in Legal Metrology Act (2009) and Rules made there under.

i) **Lot/ Code/ Batch identification**: A batch number or code number or lot number which is a mark of identification by which the food can be traced in the manufacture schedule and identified in the distribution system, shall be given on the label. However, in case of

packages containing bread and milk including sterilized milk, particulars under this clause shall not be required to be given on the label.

j) **Date Marking: "**Date of manufacture or packing", and "Expiry / Use by" shall be declared on the label. However, expression "Best before" may also be used as optional or additional information. The manner of declaration of date of manufacture or packing / Expiry / Use-by / Best Before shall be as the date, month and year using the DD/MM/YY format for products with a short shelf life of up to 3 months; the month and the year for products with a shelf life of more than three months, shall be declared in un-coded numerical sequence except that the month shall be indicated by capital letters and abbreviations (at least first three letters of the month) may be used.

In addition to the expiry or Use by, any special conditions for the storage of the food shall be declared on the label if the validity of the date depends thereon. If required, storage conditions after opening the pack may also be specified.

Notwithstanding anything contained in this regulation, an indication of the "Expiry" shall not be required for:

- ✓ Fresh fruits and vegetables, including potatoes which have not been peeled, cut or similarly treated.
- ✓ All types of wine
- ✓ Alcoholic beverages containing 10% or more by volume of alcohol
- ✓ Vinegar
- ✓ Sugar boiled confectionery
- ✓ Food grade salt for industrial use
- ✓ Solid sugars
- ✓ Chewing gum and bubble gum

"Date of manufacture or packaging" and "Expiry / Use by" shall be grouped and given at one place.

"Date and time of manufacture" shall be declared on packed meals served in airlines / railways / mobile catering units.

k) **Labelling of Imported Foods**: In addition to the requirement mentioned in these regulations, labelling requirements of imported foods shall be governed by the Food Safety and Standards (Import) Regulations (2017).

l) **Country of origin for imported foods**: The country of origin of the food shall be declared on the label of the food imported into India. Further, when a food undergoes processing in a second country which changes its nature, the country in which the processing is performed resulting in change in HS Code (Harmonized System Code, a multipurpose international product nomenclature developed by the World Customs Organization) at the 6 digit level shall be considered to be the country of origin for the purpose of labelling.

m) **Instructions for use:** Instructions for use, including reconstitution, where applicable, shall be included on the label, to ensure correct utilization of the food, or where such food requires directions for reasons for health and safety (e.g. "Refrigerate after opening").

n) **Declaration regarding Food Allergen:** The following foods and food ingredients which are known to cause allergy shall be declared separately as **Contains _____** (Name of allergy causing ingredients).

- ✓ Cereals containing gluten (To be declared as name of the cereal)
- ✓ Crustacean and their products (To be declared as Crustacean)
- ✓ Milk and milk products (To be declared as Milk)
- ✓ Egg and egg products (To be declared as Egg)
- ✓ Fish and fish products (To be declared as Fish)
- ✓ Peanuts, tree nuts (e.g. almonds, walnuts, pistachio, cashew nuts) and their products (To be declared as Nut)
- ✓ Soybeans and their products (To be declared as Soy)
- ✓ Sulphite in concentrations of 10 mg/kg or more (To be declared as Sulphite)

Provided that in case presence of ingredients due to cross contamination which are known to cause allergy may be declared separately as **"May Contain _____"** (Name of allergy causing ingredients).

Raw agricultural commodities are exempted from the allergen labelling requirements.

o) Every package of food material sold in retail but which is not meant for human consumption example Pooja water, Ghee for diya, Oil for Pooja, etc. shall bear a declaration to this effect by a symbol as stipulated below. The symbol shall consist of a black colour cross inside a square with black outline having sides of square not less than the minimum size specified in the Table mentioned in the regulation (Table-1).

3.1 Exemptions from certain labelling requirements

The following are the exemptions given in the FSS (L&D) Regulations (2020) regarding labelling of pre-packaged foods:

a) Where the surface area of the package is not more than 100 cm^2, the label of such package shall be exempted from the requirements of list of ingredients; lot number or batch number or code number; nutritional information; labelling of irradiated food, declaration of food additives; license number and logo and complete address of the importer and instructions for use, but this information shall be given on the multi-unit packages.

b) In case of liquid products marketed in bottles, if such bottle is intended to be reused for refilling, the requirement of list of ingredients shall be exempted, but the nutritional information shall be given.

c) In case of food products with shelf life of not more than seven days, the "date of manufacture" may not be required to be mentioned on the label of packaged food articles, but the "Expiry/Use by" shall be mentioned on the label by the manufacturer or packer.

d) In case of prepared food served for immediate consumption such as in hotels or by food service vendors or caterers or halwais or hospitals or at religious gathering or food served in airline/railway/passenger vehicle or any mobile unit shall accompany or display the minimum information as mentioned in the regulations at the point of sale/serve of the food.

e) The following labelling requirements are exempted if they are provided in a Barcode / Global Trade Identification Number (GTIN):

- ✓ Address of the brand owner whether or not, he himself is the manufacturer, marketer, packer or bottler, as the case may be.
- ✓ The license number of the manufacturer or marketer or packer or bottler, as the case may be, if different from the brand owner.

f) For assorted packs, shelf life declared on assorted pack should be that of the product having the earliest shelf life declared amongst the different pre-packaged food packed inside.

*****

FSSAI Registration and Licensing Procedure

Richa Singh
Scientist, Dairy Chemistry Division, ICAR-National Dairy Research Institute, Karnal

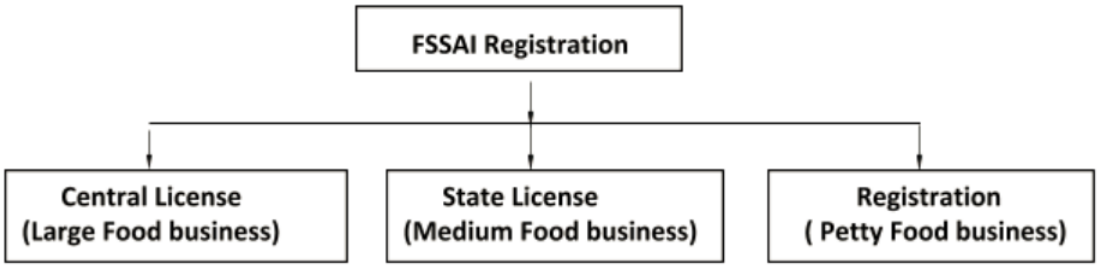
FSSAI or the Food Safety and Standards Authority is an autonomous body established under the Food Safety and Standards Act of 2006. The FSSAI is a consolidating statute related to food safety and regulation in India. It ensures the food products undergo quality checks thereby curtailing the food adulteration and sale of sub-standard products. It is responsible for the registering and licensing of the Food Business Operators (FBO) in India and it lays down the rules and regulation for running the food business in India. Under Food Safety and Standards Act, Food Safety and Standards Rules, 2011 are framed which came into enforcement from 4th August, 2013. The mandate of Food Safety and Standards Rules is to lay down science-based standards for articles of food and to regulate their manufacture, storage, distribution, sale and import, to ensure availability of safe and wholesome food for human consumption.

Every food business operator involved in the manufacturing, processing, storage distribution and sale of food products in India must compulsorily obtain FSSAI Registration or License. FSSAI Registration is different from FSSAI License in the sense that depending on the size and nature of the business, FBO should obtain the necessary registration or license in accordance with the procedures mentioned in the FSSR. Depending upon the installed capacity or turnover or location, applicant premises are eligible for the license such as basic license, central license, and state license. Obtaining a FSSAI license or registration can provide the food business legal benefits, build goodwill, ensure food safety, create consumer awareness, and assist in business expansion and it also helps regulate, manufacture, storage, distribution and sale of import food.

REGISTRATION AND LICENCING OF FOOD BUSINESS

FSSAI registration is done for “Petty Food Manufacturer”. The “Petty Food Manufacturer” means any food manufacturer, who’s production capacity of food (other than milk and milk products and meat and meat products) does not exceed 100 kg/liter per day procurement or handling and collection of milk up to 500 litres of milk per day. In terms of turnover any FBO having a turnover of less than 12 lakhs per annum must go for basic FSSAI registration.

Procedure for registration: Every petty Food Business Operator shall register with FSSAI by submitting an application in Form A under Schedule 2 of FSSAI Regulations. This application can be accepted or it may be rejected by the Department within 7 days from the date of receipt of an application and the rejection has to be intimated to the applicant in writing. If the application is accepted, then the department will grant a registration certificate with the registration number and FBO should prominently display the certificate of registration at the place of business.



For all other FBO apart from small-scale business, FSSAI license has to be obtained. FSSAI License can be classified into two categories i.e. State FSSAI License and Central FSSAI based on the size of the business whether it is a medium scale or large scale business. To apply for State License the FBO must have a turnover between Rs 12 lakh to Rs 20 crore. Other conditions include manufacturing units having capacity of 2MT per day, dairy units handling business up to 5000 liters per day. 3 star hotels and above, repackers, relabeling units, clubs, caterers all catering business irrespective of their turnover need to apply for the license. The tenure of the license being maximum of 5 years and minimum of 1 year. To apply for a central license the FBO must have a turnover exceeding Rs. 20 crores and needs to have operations in two or more states. Dairy units including milk chilling units equipped to handle or process more than 50,000 litres of liquid milk/day or 2500 MT of milk solid per annum, all food processing units including relabellers and repackers having installed capacity more than 2 MT/day except grains, cereals and pulses milling units, 100 % Export oriented Units, all Importers importing food items including food ingredients and additives for commercial use, food catering services in establishments and units under Central government Agencies like Railways, Air and airport, Seaport, Defense, etc. All food business operators manufacturing any article of food containing ingredients which do not have a history of safe use or which are being introduced for the first time into the country. The maximum tenure is 5 years and minimum is 1 year. The license or registration number is a 14-digit number which is

printed on all the food packages. The 14-digit registration number gives details about the assembling state, producer's permit.

Non-Compliance of FSS Act by Registered or Licensed Food Business Operator

Any registered or licensed person under the FSSAI must follow rules and regulation under the FSS Act, 2006. Food safety officer conducts random inspection of the food business operator's facility and identifies the level of compliance. Based on the compliance level, the food safety officer marks it as:

1. Compliance ©
2. Non-compliance (NC)
3. Partial compliance (PC)
4. Not applicable/Not observed (NA)

On partial compliance, the food safety officer might issue an improvement notice where ever required per Section 32 of the FSS Act, 2006. However, if the business operator fails to comply with the improvement notice, FSSAI may cancel his license. On non-compliance, penalty is defined in the FSS Act, 2006.

Sr. No	Particulars	Fine
1	Food quality not in compliance with act	2 Lakh Petty manufacturer – 25,000/-
2	Sub-standard food	5 Lakh
3	Misbranded Food	3 Lakh
4	Misleading advertisement or false description	10 Lakh
5	Extraneous matter in food	1 Lakh
6	Failure to comply with Food safety officer direction	2 Lakh
7	Unhygienic processing or manufacture	1 Lakh

BENEFITS OF HAVING AN FSSAI LICENSE

There are multiple added benefits of having an FSSAI license apart from freely indulging in the manufacture and distribution of food items.

1. **Legal benefits:** Registration or licensing of food business operator requires them to pass through number of checkpoints. Securing an FSSAI license even before opening a business can help you get a tremendous legal advantage. It certifies business is eligible and qualified.
2. **Quality Assurance:** Registration or licensing by FSSAI gives an opportunity to use FSSAI logo associated with business brand name and can help in spreading trust and quality assurance among the target crowd.
3. **Business expansion:** Many partnering companies and other brands look for an FSSAI license before investing. Having an FSSAI license will help in promoting brand name as well as attracting opportunities to expand your business and increase turnover profit. Most food delivery apps require the restaurant to have an FSSAI license in its application.
4. **Spreading awareness**: Having an FSSAI license also allows FBO to help spread awareness to the masses about kitchen safety and hygiene.

*****


आत्मनिर्भर भारत