UNIT 2 METHODS OF MANUFACTURE OF FERMENTED DAIRY PRODUCTS

Structure

2.0 OBJECTIVES

After reading this unit we should be able to:

- learn the importance of fermented milk products.
- know the definitions of various fermented milk products and their composition and standards.
- understand the manufacturing details of important fermented milk products.
- name the various starter cultures, additives, fruits, nuts, etc. used in the preparation of fermented milk products.

2.1 INTRODUCTION

The use of fermented milks dates back to many centuries, although there is no precise record of the date when they were first made. The milk, which could not be preserved overnight in a tropical environment, led the Aryans to benefit with the phenomenon of fermentation. Having known the nutritional and therapeutic benefits, the Aryans have embraced dahi as a natural healthful delicacy of their diet. Ancient Vedic literature contains numerous references related to dahi, which shows its importance in the Indian diet right from the Vedic era.

Initially the souring of milk was done by natural fermentation. With the advent of science of bacteriology and nutrition, fermentation process emerged as a well-developed controlled sequence of changes in milk with the use of selective microorganisms. Selective organism produces lactic acid and may impart other beneficial effect to the product. The use of different microorganisms led the development of a wide range of milk products viz. dahi, yoghurt, shrikhand, lassi, kefir, koumiss, yakult, laben, etc. In India, dahi is being produced with varieties of taste varying with region-to-region and individual food habits. The consumption

statistics shows that about 6.9 per cent of total milk produced in India is utilized for making dahi intended for direct composition. In this chapter various types of dahi fermented milk products and their methods of manufacture will be discussed.

2.2 DAHI

Dahi, Indian curd, is a well known fermented milk product consumed by large sections of the population through out the country, either as a part of the daily diet or as a refreshing beverage. In India, dahi also known as dadhi is largely made at home using traditional kitchen recipes, involving milk of buffaloes, cows and goats. Generally a mixture of cow and buffalo milk is used. Milk is boiled and cooled, inoculated with dahi starter, usually the left over from the previous day's stock, and incubated undisturbed at ambient temperature for four to six hours until it acquires a thick consistency. Dahi is generally consumed in its original form as an accompaniment to the meal or it may be converted into raita. Dahi may be consumed as such or as sweet or savoury drink as a dessert containing sugar, spices, fruits, nuts, etc. An extensive all-India survey project on dahi revealed that there are, broadly speaking, two types of dahi prevalent in the country for direct consumption, viz. a sweet/mildly acidic variety with a pleasant flavour, and a sour variety with a sharp, acidic flavour.

i. Composition

The PFA Act deifines dahi or curd as a semi-solid product, obtained from pasteurized or boiled milk by souring (natural or otherwise), using a harmless lactic acid or other bacterial cultures. Dahi may contain additional cane sugar. It should have the same minimum percentage of fat and solids-not-fat (SNF) as the milk from which it is prepared. Where dahi or curd, other than skimmed milk dahi, is sold or offered for sale without any indication of the class of milk, the standards prescribed for dahi prepared from buffalo milk shall apply.

The Bureau of Indian Standards (BIS) specifications for fermented milk products are based on the type of culture used in their preparation. Mild dahi is made from mesophillic lactococci. Leuconostocs may be adjunct organisms for added buttery odour and flavour. Sour dahi contains additional cultures belonging to the thermophillic group, which are generally employed in the manufacture of yoghurt. These thermophillic organisms grow rapidly at 37-45^{o}C, producing dahi in less than 4 hours.

Like dahi, yoghurt is a semi-solid fermented product made from a standardized milk mix by the activity of a symbiotic blend of *Streptococcus thermophilus* and *Lactobacillus delbrueckii subsp. bulgaricus* cultures. For brevity we shall term the yoghurt culture organisms as ST and LB and typical dahi organisms as LL. The body and texture of yoghurt depends largely on the composition of milk employed in its manufacture. Although milk of various mammals can be used for making cultured dairy products, their industrialized production is mainly based on milk of cows and buffaloes. The composition of various milks used in the manufacture is given in Table 2.1.

Table 2.1. Composition of milk used in the preparation of cultured dairy foods

Mammals	Fat	Caseins	Whey proteins	Lactose	Ash	Total solids
Cow	3.7	2.8	0.6	4.8	0.7	12.7
Buffalo	7.4	3.2	0.6	4.8	0.8	17.2
Goat	4.5	2.5	0.4	4.1	0.8	13.2
Sheep	7.4	4.6	0.9	4.8	1.0	19.3
Mare	1.9	1.3	1.2	6.2	0.5	11.2
Sow	6.8	2.8	2.0	5.5	--	18.8

ii. Classification

In a country as big as India, the consumers have different taste preferences for traditional products varying from region to region. This made the traditional products available with a varied taste. Dahi is also made in different varieties with region specific tastes. The technological developments have led to the commercialization of this pro duct. Dahi may be classified on the following basis.

- Dahi is used for consumption, production of desi butter
- Preparation of chakka, shrikhand and lassi.
- Dahi is prepared from whole milk, skim milk, standard milk, and special milk.
- Dahi is also prepared by addition of sugar and fruits.
- Acidity of normal dahi is less than 0.7% while acidity of sour dahi is more than 0.7%.

Dahi made from buffalo milk produces a thick bodied product because of its high SNF content. It is recommended to make dahi/ yoghurt from a mix containing 11-13 percent SNF. The increased protein content in the mix results in a custard like thick consistency following the required fermentation. Higher milk solids also keep the product from wheying off. Dahi prepared from whole milk contains about fat 5-8, protein 3.2 – 3.4 lactose 4.6 – 5.2, Ash 0.70 – 0.72, and titratable acidity 0.60 –0.80 percent.

iii. Method of Manufacture

i) Traditional method: In this method dahi is prepared at small scale, either in the consumer's household or in the confectionary (Halwais) shop. In the household, the milk is boiled, cooled to room temperature, inoculated with 0.5 to 1.0 percent starter (previous day's dahi or butter milk) and then incubated undisturbed for setting for about overnight. In cold weather, the dahi setting vessel is usually wrapped up with woolen cloth to maintain appropriate temperature. In the confectionary shops, the method employed for preparation of dahi is more or less same except that the milk is concentrated in a open pan before inoculation and usually dahi is set in a earthenware.

ii) Standardized method: Process on the basis of scientific lines has been developed for dahi making in the organized sector. Fresh, sweet, good quality milk is received, pre-heated and subjected to filtration and clarification. The milk is standardized to 2.5 to 3.0 percent fat and 10 percent solids not fat, pre-heated to 60^{o}C and homogenized single-stage at a pressure of 176-kg/sq cm. The milk is heated to 85 – 90^{o}C for 15-30 minutes, cooled to 22-25^{o}C and inoculated with 1-2 percent of specific dahi starter culture. It is then filled in suitable packaging containers of the appropriate size and incubated at 22-25^{o}C for 16-18 hours. After proper setting of

the dahi, the acidity of dahi reaches 0.6 to 0.7 percent and a firm curd is formed. The curd is cooled by circulating chilled water or air around the containers and then transferred to cold room maintained at about 4-5°C. The flow diagram for manufacture of dahi is presented here under (Fig. 2.1).

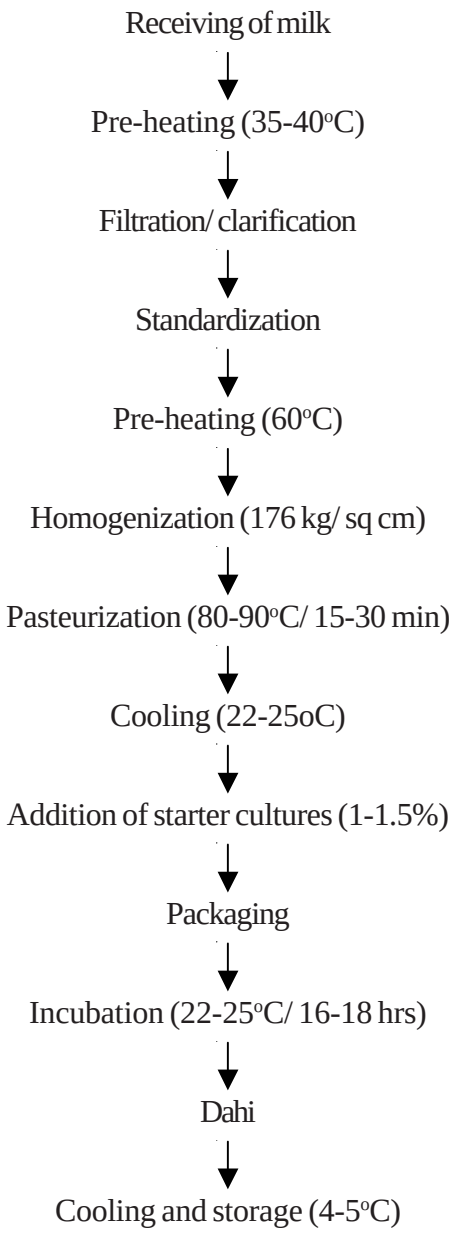

Fig. 2.1 Manufacture of Dahi

2.3 MISHTI DAHI

Mishti dahi or mishti doi is a popular traditional sweetened fermented milk product. The eastern parts of India, especially in West Bengal, Assam, Bihar and Orissa, the sweetened variety of dahi known as Mishti dahi, Lal dahi or Payodhi is quite popular. The product is prepared by the Halwais on a small scale. It is a delicacy of choice during religious festivities and is considered an auspicious item to serve while starting journey or any important work. The product is commonly sold in earthen pots of varying sizes, and served chilled.

i. Composition of Mishti Dahi

Mishti dahi is a fermented milk product, having creamish to light brown colour, firm body, smooth texture, sweet-acidic flavour, and pleasant aroma. As such, there is no prevention of food adulteration (PFA) Act or BIS standards for mishti dahi. In

the absence of legal standards, mishti dahi differs in terms of chemical composition as well as sensory attributes. The typical composition of mishti dahi is given in table 2.

Table 2.2. Composition of different grades of mishti dahi

Constituent (%)	Low fat	Medium fat	High fat
Milk fat	2-3	4-5	8-9
Milk SNF	13-14	11-13	10-11
Sugar	17-19	17-18	17-18
Total solids	32-35	32-36	35-38

The quality of mishti dahi is depend upon the type of milk, level of concentration, and fermentation conditions employed in its manufacture. The effect of levels of starter culture addition on physico chemical and sensory properties of mishti dahi is given in table 2.3.

Table 2.3. Influence of amount culture on physico-chemical and sensory properties of Mishti dahi

Characteristics		Percent Inoculum			
		0.5	1.0	1.5	2.0
Acidity (%LA)	Initial	0.28-0.29	0.28-0.29	0.28-0.29	0.28-0.29
	Final	0.72-0.75	0.78-0.80	0.80-0.84	0.88-0.90
	Fold Increase	2.57-2.68	2.75-2.85	2.85-2.86	3.10-3.14
PH	Initial	6.32-6.35	6.32-6.35	6.32-6.35	6.32-6.35
	Final	4.62-4.65	4.53-4.61	4.49-4.56	4.42-4.49
Diacetyl + AMC (µg/g)		18-19	20-21	22-25	25-28
Average flavour score (Maximum, 9.0)		6.86	7.88	7.38	7.09
Average texture score (Maximum, 9.0)		6.71	8.05	7.83	7.24
Curd tension (g)		20-22	28-29	25-27	21-23

ii. Method of Manufacture of Mishti Dahi

i) **Traditional method:** Traditionally, mishti dahi is prepared from cow or mixed milk. The fresh good quality milk is boiled with a required amount of sugar and partially concentrated by simmering over a low fire. This heating is continued for quite some time during which milk develops a distinctive light cream to light brown caramel colour and flavour. The content is then cooled to ambient temperature and cultured with dahi (lactic) culture). It is then filled into earthen pots of consumer size or bulk size vessels and incubated over night. Normally the curd is set within 12-14 hours. After firm setting of curd, it is transferred to a cool place or stored under refrigeration.

ii) **Industrial production:** In the organized sector, mishti dahi is manufactured employing improve technological process. A wide range of milk products for sourcing milk solids is used in the production of mishti dahi. For this purpose, milk solids are used from fresh cow/ buffalo milk, cream, skim

milk powder (SMP), whole milk powder (WMP), evaporated whole milk, sweetened condensed milk and white butter.

The required ingredients are blended in proper proportion, keeping in view the final compositional standard of the product in terms of fat, SNF, and sugar. There is a need to select fresh and good quality ingredients in relation to microbial and sensory quality. The raw material (milk) used for mishti dahi preparation should be fresh, free from off-flavours and has negative clot-on-boiling test.

The most common sweetening agent used in preparation of mishti dahi is cane sugar. Other sweeteners such as corn sugar, corn syrup, and also sugar or maltose can be used as sweetening agent. Some times in preparation of some special varieties of mishti dahi, fresh palm jaggery is used as a sweetener. Commercially cane sugar of high microbiological quality and free from extraneous matter is used as sweetening agent.

Mishti dahi is coloured and flavoured commonly with caramel. Caramel is prepared from heating sugar and it is available commercially in a viscous form (76% TS). Caramel is soluble in water and having a specific gravity of 1.315 to 1.345. Synthetic flavours like caramel, vanilla, cardamom, rose, pineapple, etc may also be used. Fruits and dry fruit, nuts may also be used for developing a wide variety of mishti dahi.

The most critical and important step in the manufacture of the mishti dahi is the selection of appropriate type of starter culture since it affects the flavour, consistency and acidity development in the presence of sugar and caramel at relatively higher TS levels. As such starter culture is regarded as heart of mishti dahi preparation. Mixed strain culture may be used since it yields a superior product and most reliable under variable processing conditions. The optimum activity of the mishti dahi culture is expected in a narrow temperature range of 40-42^{o}C. Normally a good starter culture with 1.0 percent inoculum develops 0.70 percent acidity within 6-8 hours.

Process: The required quantities of milk, cream, skim milk powder and sugar are blended. Caramel is added normally at the rate of 0.10 to 0.12 per cent. The mix is heated to 80^{o} – 90^{0}C in a vat or a plate heat exchanger. Various time- temperature combinations have been tried but heating the mix to 85^{o}C for 15 minutes resulted in a highly desirable flavour and textural qualities. After heat treatment, the mix is cooled to 40-42^{o}C either employing heat exchanger or by circulating chilled water in the jacket of vat. The starter culture is added to the mix at the rate of 1.0 percent and thoroughly mixed using stirrer. Thereafter, the mix is filled in samtized cups of required sizes and covered with lids. The cups are properly heat sealed to make them airtight and prevent leakage. These cups are then incubated at 40-42^{o}C for about 6-8 hours till the acidity develops to about 0.70 to 0.80 percent LA. At this acidity the mix will well set and a desired consistency and firmness is attained. After proper setting, these cups are transferred to a cold store of 4-5^{o}C temperature. For long storage, normally the temperature of cold store is maintained at 0^{o}C.

iii) **Production of Mishti Dahi from buffalo milk:** Fresh buffalo milk is standardized to 3.5% fat and 9.0% SNF, heated to 65^{o}C in a plate heat exchanger and homogenized at a pressure of 56 kg/cm^{2} (one stage). Milk is concentrated at 1.44 fold in a vacuum evaporator. After adding cane sugar, the

milk is heated at 85°C for 5 min to generate cooked flavour. The mix is water cooled to 40°C before inoculation with the mixed culture (LF-40). In some cases, sugar caramel, jaggery and artificial colours are added to impart brown colour. The inoculated mix is aseptically distributed into pre-sterilized polystyrene containers (200 ml) and mechanically transferred to incubation chamber at 40°C. After 7 h of incubation, the product is shifted to cold store maintained at 4°C. During gel formation, milk must remain stationary. In the flow chart (Fig.2), fermentation is designed as a batch process. In all post fermentation activities, gel should be subjected to a minimum amount of external influences. The influences of varying inocula on physico-chemical and sensory properties of Misti dahi are shown in Table 2.3.

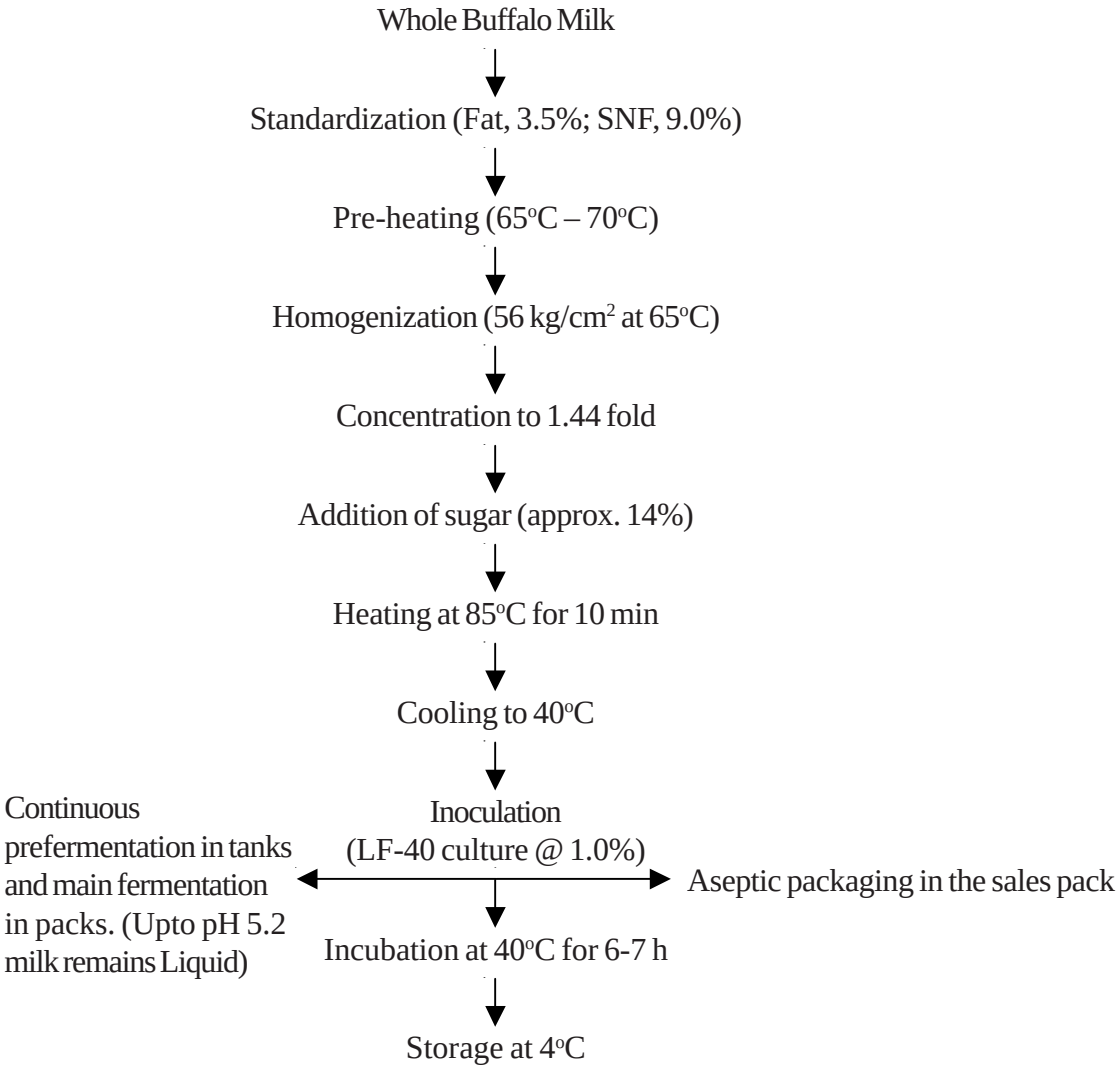

Fig. 2.2 Flow diagram for manufacture of Mishti Dahi

Check your Progress 1

1) Define fermented milks.

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2) Give classification of dahi.

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3) Write down the method of manufacture of dahi.

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4) Describe mishti dahi.

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5) Give composition of different grades of mishti dahi.

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6) Write down the industrial production of mishti dahi.

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2.4 SHRIKHAND

Shrikhand, a semi-solid, sweetish-sour fermented milk product, is very close to flavoured quarg of Germany. It is a popular dessert of Gujarat, Maharashtra and Karnataka and forms part of meal especially on festive occasions. Shrikhand is prepared by fermentation of milk with lactic acid bacteria, expulsion of whey from the curd, followed by mixing with sugar, flavouring and spices. The composition of this product is: 34-40 percent moisture, 43-45 percent sugar, 4-6 percent fat, and 10-12 percent milk solids-not-fat.

i. Standards

The standards prescribed for Shrikhand by the Bureau of Indian Standards (BIS) and under the prevention of food adulteration act (PFA) are presented in table 2.4.

Table 2.4. PFA/BIS standards for shrikhand

	BIS	PFA
Total solids (per cent, by mass), minimum	58.0	58.0
Milk fat (in dry matter, per cent by mass), minimum	8.5	8.5
Milk protein (in dry matter, per cent by mass), minimum	10.5	10.5
Titratabel acidity (per cent lactic acid), maximum	1.4	1.4
Sucrose (in dry matter per cent by mass), maximum	72.5	72.5
Total ash (in dry matter per cent by mass), maximum	0.9	0.9
Coliform count, cfu/g, maximum	--	10.0
Yeast and mould count, cfu/g, maximum	--	50.0

ii. Chemical Composition

The chemical composition of shrikhand depend upon the type and quality of milk, processing conditions employed, and fruits/spices used. The physico chemical properties and chemical composition of shrikhand are presented in table 2.5. and 2.6, respectively. The chemical composition of Shrikhand sold in Gujarat is given in table 2.7.

Table 2.5. Composition of dahi, chakka, and shrikhand

Constituent	Dahi	Chakka	Shrikhand
Total solids (%)	9-10	22-23	57-60
Fat (%)	Trace	Trace	5-6
Proteins (%)	3.7-3.9	13.5-14	6.5-7.0
Sucrose (%)	--	--	40-43
Ash (%)	0.72	0.95-1.08	0.49-0.55
Reducing sugar (%)	4.5-4.7	3-3.25	1.6-1.7
Titratable Acidity (%)	0.9-0.95	2.1-2.2	1.05-1.10
PH	4.4-4.6	4.4-4.6	4.4-4.6

Table 2.6. Physico-chemical parameters of shrikhand marketed in Gujarat and Maharashtra

Parameters	Average values		
	Maharashtra[1]	Gujarat[1]	Industrial[2]
PH	4.09	4.10	4.33
Acidity (% as lactic acid)	1.30	1.08	1.13
Soluble nitrogen (%)	0.21	0.29	0.29
Free fatty acids (% as oleic acid)	0.58	0.40	0.26
Penetration value (mm) at 10°C	28.54	27.35	32.71

[1] Average values of product made in the un-organized sector.

[2] Average values of product made by the mechanized process in the organized sector.

Table 2.7. Chemical composition of shrikhand sold in Gujarat

Constituent	Traditional shrikhand	Industrial shrikhand
Moisture (%)	40.52	35.11
Fat (%) DM*	8.27	9.25
Proteins (%) DM	9.53	12.53
Lactose (%) DM	3.74	2.59
Sucrose (%) DM	76.25	70.00
Ash (%)	0.530	0.683
Titratable acidity (% LA)	1.075	1.310
PH	4.10	4.33
Soluble nitrogen (%)	0.290	0.286
FFA (% oleic acid)	0.395	0.265

iii. Manufacture of Shrikhand

The method of manufacture of shrikhand involves the preparation of curd or dahi by fermentation of milk with starter culture, preparation of chakka by draining whey from the curd and blending additives like sugar, color, flavour, species and fruits to obtain a desired composition and consistency.

i) Traditional method: The traditional method of making shrikhand consists of preparation of dahi by culturing cow or buffalo milk with natural starter culture (curd from previous batch), preparation of chakka by draining whey from dahi followed by blending sugar, colour, flavouring materials and spices.

Milk of cow or buffalo, or mixed milk is heated to boiling and then cooled to 30°-35°C. It is inoculated with dahi (lactic culture) @ 0.5 to 1 per cent from the previous day's production. Milk is left at room temperature (30°-35°C) until it sets firmly. It is then stirred and hung in a muslin cloth for 10 to 12 hours, to drain off whey. The product so obtained is called chakka or maska. The chakka yield is about 65 kg per 100 kg of milk, depending upon the composition of milk.

The chakka is mixed with the required amount of sugar (usually 50-100 per cent of curd quantity), flavour, colour, herbs and spices. Commonly used additives include saffron, cream, charoli, almonds, nutmeg, cashew nut, mango pulp, raisins, and seasonal fruits. The shrikhand yield is about 1.5 to 2.0 kg per kg of chakka used. Shrikhand is served chilled. Consumers in Gujarat prefer its sweet variety while those in Maharashtra prefer the tangy/soury variety.

ii) Industrial method: The fully mechanized and continuous process has been developed for industrial production of shrikhand. With the development of the dairy industry, shrikhand production has become industrialized. The process consists of centrifugal separation of whey from the curd and the mechanical mixing of 'chakka;, sugar and species, making the entire process hygienic as well as labour and time saving. Fig. 2.3 shows the industrial method of shrikhand manufacture. Normally skim milk is used for making dahi for the manufacture of Shrikhand. By using skim milk, not only are fat losses eliminated, but faster moisture expulsion and less moisture retention in the curd are achieved. Skim milk is heated to 85°C for 30 min. This heat treatment results in denaturation of β-lactoglobulin, which in turn interacts with casein on acid coagulation, thereby increasing the yield. Also high temperatures are believed to result in the alteration of proteins in milk, which favours the growth, and activity of starter culture. Also, application of heat to milk results in the destruction of certain heat labile inhibitors as well as many of the competing microorganisms that are present in raw milk. The industrial production involves the following steps:

Preparation of dahi/curd: Skim milk (9% SNF, 0.05% fat) is heated to 90°C for 15 seconds in HTST pasteurizer, cooled to 30°C and inoculated with 0.25 – 0.50 per cent dahi culture of mixed strains. After eight hours of inoculation period, the required acidity (0.8 to 1.0% lactic acid) is achieved, and the curd is ready for further processing.

Preparation of chakka: Chakka/maska is prepared by separating the whey from dahi. Earlier, a 28 inch diameter basket centrifuge at 1,100 rpm was used that produced 80 kg of curd per hour. Now, the process has been upgraded by using a quarg separator. Its capacity is 2,500 kg of curd per hour.

Preparation of shrikhand from chakka: Shrikhand is prepared by adding sugar at the rate of 80% of the amount of chakka and mixed in a planetary mixer. Required

amount of plastic cream (80% fat) is added along with sugar to chakka so as to give at least 8.5 per cent fat in the finished product on dry matter basis.

The processing conditions for the manufacture of shrikhand have been standardized. The final product contains 5 per cent fat, 42 per cent sugar and 60 per cent total solids. The acidity of the product is usually between 1.10 and 1.40 per cent (expressed as lactic acid). The protein content of the product is 10.5 percent.

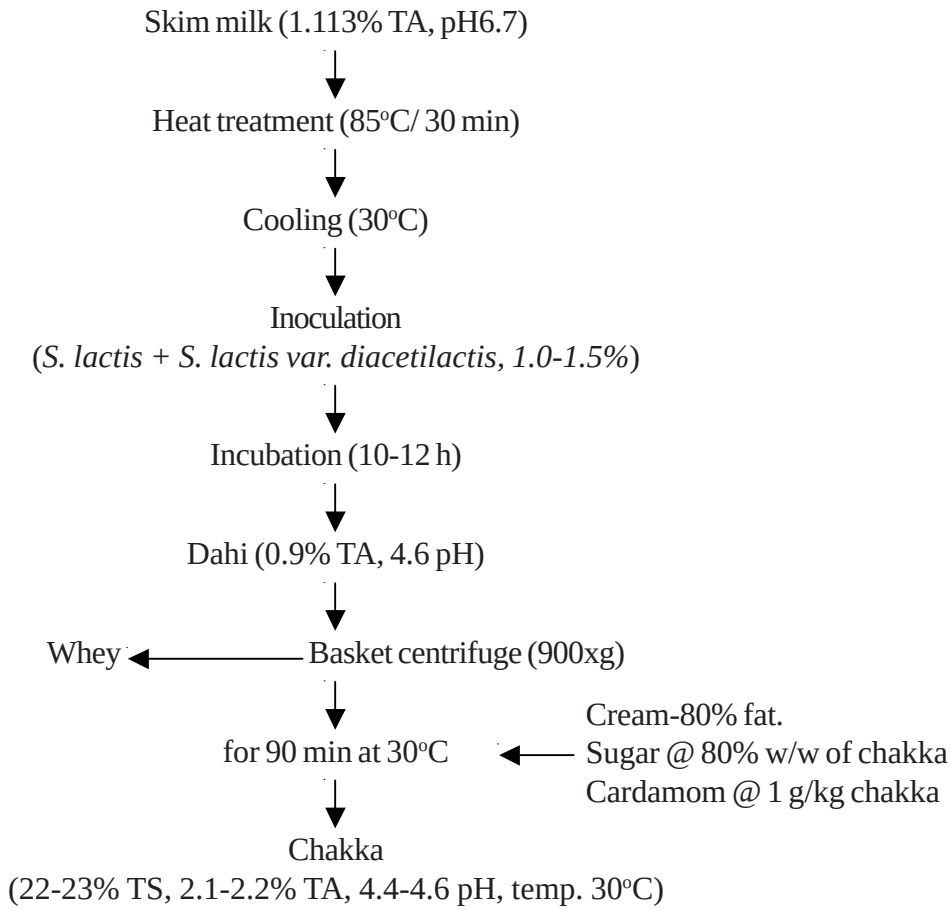
Upgraded process for shrikhand manufacture.

Starter cultures: The use of right type of culture is essential for the manufacture of shrikhand. A mixed culture containing *Lactococcus lactis subsp. Lactis, Lactococcus lactis subsp. diacetilactis/ Leuconostoc, Lactococcus lactis subsp. cremoris* in the ratio of 1:1:1 may be used. Other recommended cultures are yogurt containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii subsp. bulgaricus* (1:1) or LF-40, a culture compromise of *Lactococcus lactis subsp. Lactis* and *Lactococcus lactis subsp. diacetilactis.*

Separation of whey from curd: it is carried out in a quarg separator that can handle 2,500 kg of curd input per hour. This permits to scale up the production to 8-tonnes/ day with installation of other equipment of matching capacity. This process has been further refined for enhancing shelf life of shrikhand by pasteurization.

Mixing of chakka with cream and sugar: The mixing capacity in the earlier process was limited since the planetary mixer could only handle up to 40 kg/batch.

Packaging of Shrikhand: The shrikhand is packaged in pre-formed polystyrene cups/containers of various sizes ranging from 100 g to 1.0 kg. However, small manufacture sell the product in paper-board boxes.



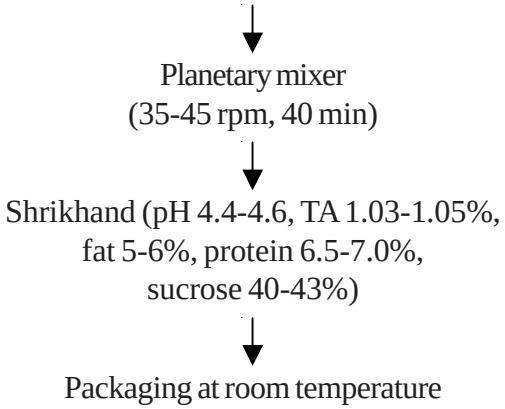


Fig. 2.3. Industrial method of shrikhand manufacture

2.5 LASSI

Lassi (stirred dahi) is a ready-to-serve fermented milk beverage popular in India particularly in summer months. Good quality lassi should have creamy consistency, smooth texture, glossy sheen and white colour with yellowish tinge. Mild acidic flavour and sweetish taste of lassi make it a refreshing soft drink. It is flavoured either with salt or sugar and other condiments or spices like ginger, coriander, and mint, depending on regional preferences. Lassi is obtained from pasteurized whole milk or partly skim milk, cultured with lactic and aroma/flavour producing organisms. In many parts of the country products, like butter milk, chhach, mattha obtained after churning of sweet cream, or whole milk dahi and removal of butter are termed as lassi and usually consumed in salted or spiced form. Also a product prepared from cultured skim milk, commonly known as cultured butter milk is classified as lassi.

i. Chemical Composition

Lassi is a white to creamy-white viscous liquid with a sweetish, rich aroma and pleasant mild acidic taste. The chemical composition of lassi depends on the type of milk, initial composition of milk, level of concentration of milk solids and the sugar level. The proximate composition of lassi is given in table 2.8.

Table 2.8: Proximate composition of lassi

Milk fat	-	1.5 – 3.8%
Milk TS	-	9.00%
Sugar	-	13 – 20%
Sodium dihydrogen phosphate optional	-	0.5%
Low methoxy Pectin optional	-	0.5%
Acidity (minimum)	-	0.7% LA

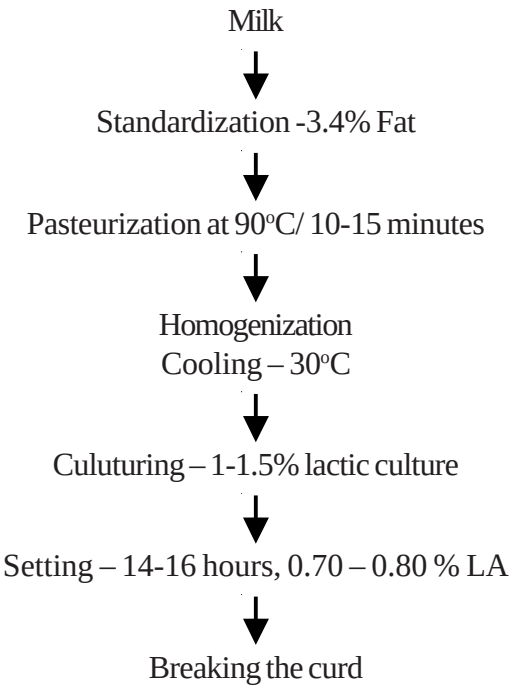
ii. Manufacture of Lassi

Production of lassi has been confined, to a large extent, to the households and local halwais mainly because of non-availability of a standardized technique for the manufacture of uniform quality lassi and its limited shelf life. In 1972 the technology was standardized at NDRI, Karnal and regular production of lassi started. The method of manufacture of lassi involves standardization, heating and cooling of milk to inoculation temperature, addition of starter culture and setting of milk. Sugar @ 12-15% of milk dissolved in equal quantity of water is added in the form of a syrup

which has been pasteurized and cooled separately. Smooth consistency of lassi is obtained by homogenization of the mix. Flavour is added before packaging. In general, the quality of milk, starter culture and the method of manufacture influence the quality of lassi. Chemical quality of milk is important for desired body and texture and consistency and to meet the legal requirements, if any. But the more important effect of chemical and bacteriological quality of raw milk is on the growth of starter organisms. Therefore, the milk, which serves as a growth medium for the microorganisms must be of high microbial quality and free from mastitis milk, lipolytic rancidity, residual antibiotics and germicides. There should not be any bacteriophage contamination.

Pooled milk is considered to be the most suitable for the manufacture of fermented milk products, like, yoghurt, dahi, shrikhand etc. A suitable heat treatment is applied to milk to make it free form most of the vegetative cell of microorganisms associated with raw milk. However, some spore formers and stable enzymes remain unaffected by the commonly employed heat treatment in the manufacture of fermented milks. The basic role of starter culture is to bring about acid coagulation of milk and impart characteristic flavour. The culture must be pure, active and free from gas producing microorganisms. Presence of more than one type of lactose fermenting microorganisms in the starter culture is required for the production of diacetyl flavour in dahi. A lactic culture comprising of *Lactococcus lactis subsp. lactis, Lactococcus lactis subsp. cremoris* and *Lactococcus lactis subsp. diacetilactis* is used for dahi for lassi making. Setting of milk is terminated at an acidity of 0.70 – 0.80 per cent LA. To the set curd sugar syrup is added which requires sufficient heat treatment (80-90^{o}C) to prevent microbial contamination through sugar. It is also essential to cool the syrup to room temperature before addition to dahi to prevent hardening of fine curd particles and whey separation. Homogenization prevents cluster formation, rising of fat to the surface and improves consistency.

In a typical method of manufacture of lassi, standardized milk (4% fat) is heated to 90^{o}C for 10 min and cooled to 25^{o}C before addition of starter culture (1%). Cultured milk is incubated for 12-16 hr at 25-28^{o}C, the set curd is broken by stirring and sugar syrup is mixed. The mixture is homogenized and packaged after the addition of flavour. On an average the product contains 3 per cent fat., 6-7 per cent SNF and 10-11 per cent sugar. The acidity ranges from 0.6 to 0.7% LA. Flow chart for mechanized production of lass is depicted in Fig. 2.4.



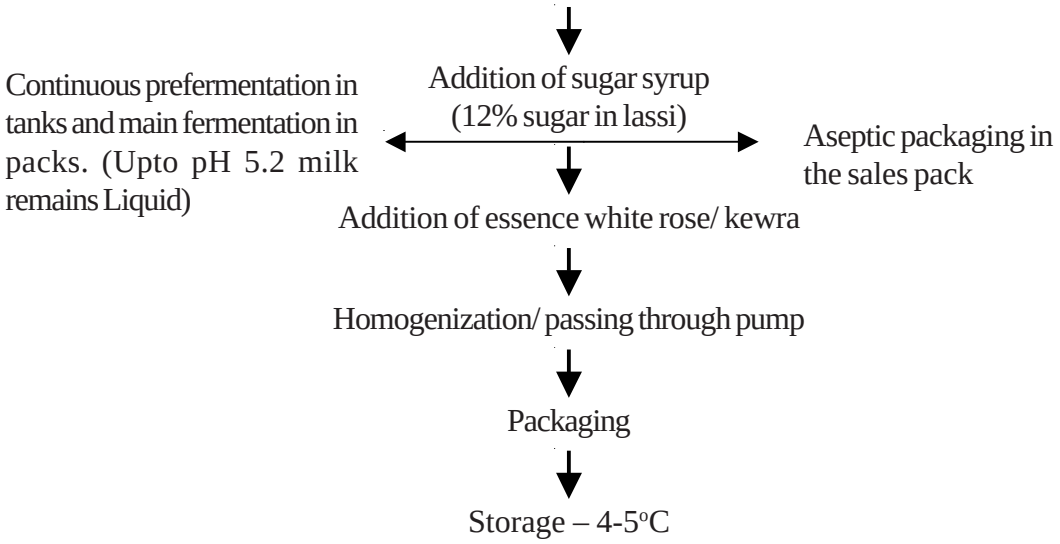


Fig. 2.4 Flow diagram for manufacture of lassi

iii. Technical Developments

Lassi keeps good only for a day or two at room temperature. Under refrigeration, the keeping quality of lassi is extended considerably. Further extension of shelf life is achieved by UHT processing after fermentation and packaging aseptically. Wheying off may occur but it can be avoided by using a suitable stabilizer and proper processing conditions.

UHT Lassi: Significant advancements have been made towards the industrial production of lassi through application of UHT. Standardized milk (9-10% SNF and 0.5-1.0% milk fat) is warmed to 85°C for 30 minutes or 91°C for 2.5 to 5 minutes and cultured with suitable lactic culture (dahi culture at 31°C). It is then fermented at 22°C to lower its pH to 4.5. Set curd is broken with the help of a stirrer while sugar solution (30% in water) is added to give 8-12 percent sugar concentration in the blend. Lassi is then homogenized at 13.7 Kpa (2000 psi) and UHT processed at 135-145°C for 1-5 seconds and packaged aseptically employing standard equipment.

Directly acidified milk beverage: The addition of organic acids such as acetic, fumaric, lactic, tartaric, citric, and phosphoric acid to milk result in the formation of a coagulum at pH less than 4.6. Employing this principle a method for the manufacture of long life directly acidified milk beverage has been developed at NDRI, Karnal. Toned milk is diluted with water in the ratio of 7:3, preheated to 45°C and additives like sugar (18%), carboxyl methyl cellulose (0.8%), trisodium citrate (0.09%) are added and mixed. The milk is pasteurized at 70-75°C and cooled to 6-8°C. The pH of milk is then adjusted to 3.75 with the addition of diluted phosphoric acid (2.25 N) followed by heating to 65°C, addition of colour and homogenization. The homogenized mix is cooled to room temperature prior to addition of flavour and bottling, the filled bottles are finally sterilized at 110°C for 5 min, cooled and stored. The beverage has a shelf life of 120 days at 5°C and 75 days at 30°C.

Lassi Powder: In order to meet the seasonal and regional requirements of lassi, a technology has been developed for the manufacture of lassi powder, which upon reconstitution yields lassi like beverage. The method involves concentration of skim milk by reverse osmosis process, standardization of the concentration with cream to contain 10 per cent fat and 30 per cent total milk solids, inoculation with starter culture and setting of curd. The curd is broken by agitation to obtain a smooth slurry which is subsequently spray dried under predetermined conditions. Sugar is dry

blended. The powder on reconstitution with water yields lassi-like beverage. Acceptability of the beverage could be enhanced by fortification with fruit juices. The lassi powder was found to contain moisture 5 per cent, fat 29-31 per cent and protein 23-34 per cent.

Check your Progress 2

1) Define shrikhand.

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2) Write down the PFA/BIS standards for shrikhand.

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3) Give industrial method of shrikhand manufacture.

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4) What is lassi?

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5) Give proximate composition of lassi.

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6) Give flow chart for mechanized production of lassi.

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2.6 YOGHURT

The basic ingredients of yoghurt are milk and microflora. The milk is converted into yoghurt by growing within it specific lactic acid bacteria and souring it under defined conditions. According to FAO/WHO (1977) "Yoghurt is a coagulated milk product obtained by lactic acid fermentation through the action of *Lactobacillus bulgaricus* and *Streptococcus delbrueckii subsp. thermophilus,* from milk and milk products (Pasteurized milk or concentrated milk), with or without optional additions (milk powder, skim milk powder, whey powder, etc.). The microorganisms in the final

product must be viable and abundant".

The origin of yoghurt is not clear. According to some sources yoghurt originated in Asia, where the ancient Turks lived as nomads. The first Turkish name appeared in the 8th century as "Yogurut" and was subsequently changed in the 11th century to its present form. A dried type of yoghurt was called "Kurut: and a beverage type "Suvuk yoghurt". According to still some authors, yoghurt originates from the Blakans. The inhabitants of Thrace, known for breeding large flocks of sheep, used to make soured milks called "Prokish" which later became yoghurt. Originally yoghurt was made from sheep and buffalo milk and partly from goat and cow milk in containers of wood or argil. Propagation was carried out by using a small quantity of the previously coagulated milk to seed the next batch of boiled milk. Yoghurt was used primarily in the human diet for direct consumption, either as a natural product or fortified with various vegetables and spices, but also for cooking and baking purposes.

Ancient physicians of the near and middle East prescribed yoghurt or related soured milks for curing disorders of the stomach, intestines and liver and for stimulating the appetite. In the early part of the 20th century Metchnikoff (1845-1916) in his 'theory of longevity" noted the beneficial effect of yoghurt in the human diet. Although this theory exaggerated the value of yoghurt, it significantly influenced the spread of the product to many countries of Europe and promoted extensive studies by subsequent workers.

i Definition

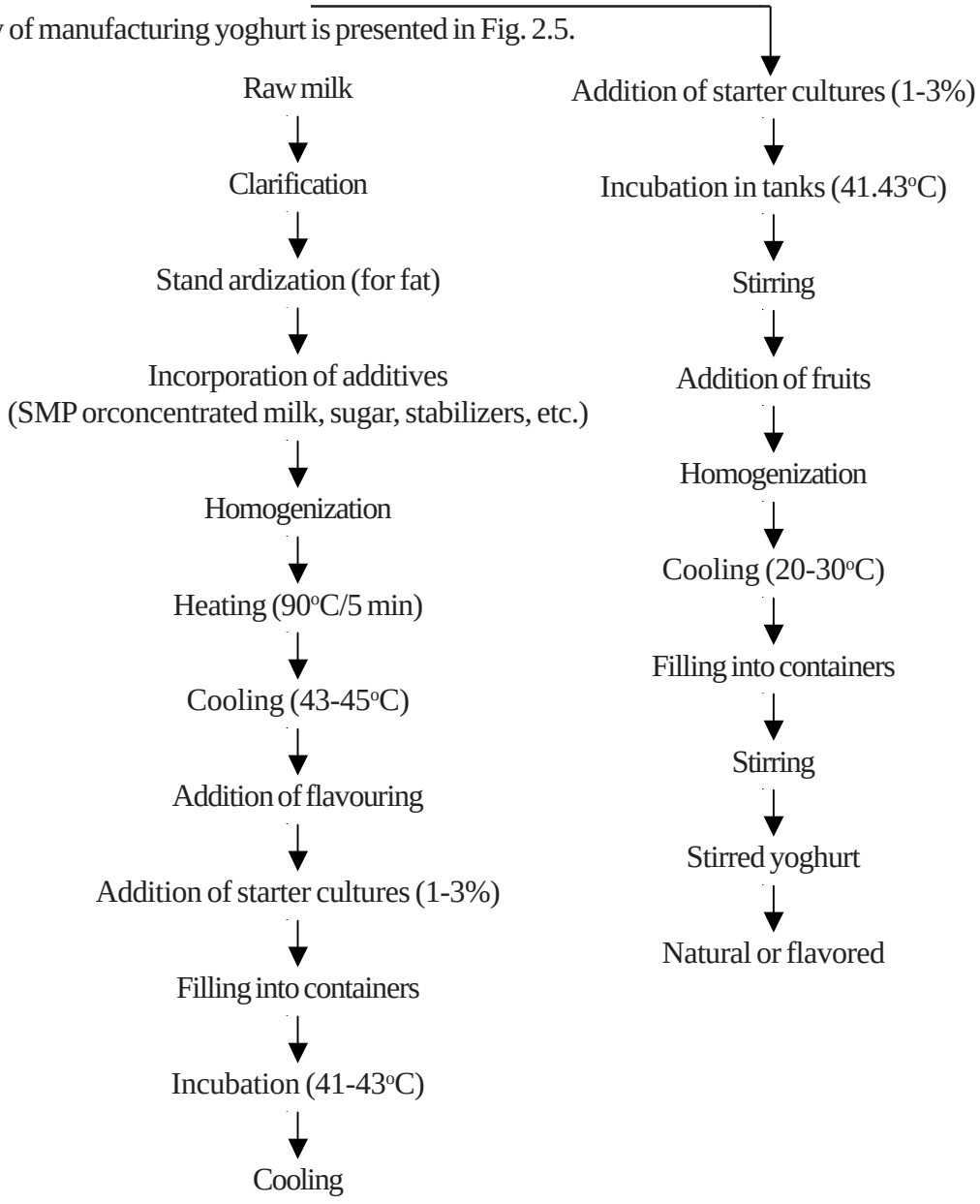
Yoghurt is a coagulum obtained by lactic acid fermentation of prescribed milk or milk products by the action of *Lactobacillus delbrueckii subsp. bulgaricus* and *Streptococcus thermophilus*, the addition of additives is optional. The final product should contain large quantities of the above microorganisms. Yoghurt is characterized by a pungent, fruity small and acid taste. It has a firm body like dahi. Commercial yoghurts are divided into three main categories, i.e.. plain/natural, fruit and flavoured, and these different types of yoghurt are manufactured in many forms such as set, stirred, liquid/drinking, frozen and dried/instant types. The international standards for types of yoghurt are given in table 2.8.

Table 2.8. The international standard for different types of yoghurt (FAO/ WHO)

Type	Compositional Standard		Essential materials and additives	Optional Additives	Food additives
	Fat (%)	SNF (%)			
Yoghurt	≥ 3.0	8.2	Pasteurized milk, non-fermented butter milk, concentrated whey.	Skim milk, non-fermented butter milk, concentrated whey protein conce-rate, water soluble milk protein, food casein, caseinate, latic bacteria other than *L. bulgaricus* and *S. thermo-philus*, sugar	None
Partly skimmed yoghurt	0.5-3.0	≥ 8.2	Pasteurized concent-rated part skimmed milk, pasteurized cream		
Skimmed yoghurt	<0.5	≥ 8.2	*L. bulgaricus* and *S. Thermophillus* cultures		

iii. Method of Manufacture of Yoghurt

The technology of manufacturing yoghurt is presented in Fig. 2.5.



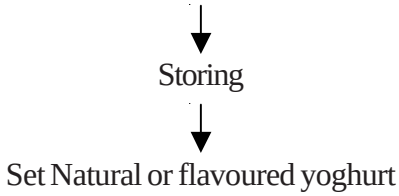


Fig. 2.5. Flow diagram for manufacture of yoghurt

(a) Process lines for yoghurt

The quality of yoghurt depends not only upon the type of raw material used and the manufacturing procedure applied but also upon the good functioning of the process equipment involved and process line.

i) Batch Method: This method was originally used in small-scale production. The manufacture of set yoghurt is carried out as follows:

The clarified milk, adjusted to a specific solids content, is heated in a jacketed vat to 90-95°C for 15-25 min, cooled to 43-45°C, inoculated with 1-3 percent yoghurt culture and thoroughly mixed with the milk and then filled into retail containers, incubated in an incubator at 41-43°C for 2-3 hours and cooling with in the same incubation chamber or in the cold store. Alternatively, incubation and cooling can be done in water trays.

In the manufacture of stirred yoghurt, heat treatment of the milk, cooling, inoculation and incubation are carried out in a jacketed vat, followed by cooling either in the same vat or in a cooler, with subsequent filling into retail containers.

With larger plants it will be desirable to include homogenization of the milk. This can be done using a plate heater or heating the milk to the homogenizing temperature (55-65°C) and then to pasteurize homogenized milk in a jacketed vat.

Both types of yoghurt can be produced as natural or plain or flavoured and fruit. Flavouring or fruit are added before incubation when making set yoghurt and after incubation and cooling when making stirred yoghurt. The addition of sugar, particularly in flavoured and fruit types, has the purpose of improving the taste of the product and masks its acidity. If flavorings are not already sweetened, sugar is added before heat treatment of the milk. The sugar concentration should not exceed 12% because of the inhibitory (osmophilic) effect on the cultures.

The main characteristics of the batch method and its process lines are as follows:

- A number of breaks during the whole process of manufacture, for standardization of the fat content, addition of milk powder, heat treatment of the milk and cooling, inoculation, etc. which involves an incomplete utilization of the processing equipment.
- A considerable consumption of energy and of time, particularly during

heat treatment and cooling of the milk and high labour costs.

- An increased chance of air borne contamination by yeasts and moulds during the manufacture due to the carrying out of discontinuous process, the use of open vats and the manual additions of cultures, fruit and flavorings.

ii) Modern Process: Modern process lines for yoghurt are used in medium or large scale production. The following factors contributed to the introduction of modern process lines:

- Standardization of the fat content in milk by using specially designed equipment.
- Increasing the solids content in milk, by concentration of the milk using specially designed evaporating units concentration of the milk by 10-15% (raising of dry matter for about 2-3%) normally gives an optimum solids content. This method is usually used in large scale production. Alternatively, 1-3% skim milk powder may be added for increasing the solids content in milk.
- Homogenization at 55-65^{o}C under a pressure of 2000-2500 psi in a homogenizer, usually before heat treatment of the milk.
- Heat treatment of the milk in pasteurizers at 90^{o}C for 5 min and in UHT sterilizers (direct and indirect heating) at 135-145^{o}C for few seconds, with subsequent cooling to the fermentation temperature.
- Culturing of milk by the addition of bulk starter (1.5 – 2.0%) with subsequent stirring for few minutes.
- In manufacturing stirred yoghurt, incubation is carried out in a series of insulated tanks working in rotation. After the completed incubation (41-43^{o}C for 2-3 hrs) the yoghurt is discharged by a positive pump to the plate or tube cooler. Cooled yoghurt is transferred to a pair of buffer tanks which continuously supply it to packaging machines. On the packaging line, previously pasteurized flavouring ingredients are continuously added in-line by a positive metering pump and mixed with the yoghurt.
- In the manufacturing of set yoghurt, the inoculated milk in a pair of mixing tanks is fed to packaging machines for filling into retail containers. On this route, previously pasteurized flavouring or fruit concentrate may be added in line by a metering pump and mixed with the yoghurt milk. The filled containers are transferred to incubation chambers for incubation until a pH 4.7 is reached. Cooling can be done either within the same chambers or in the cold store.
- Processing equipment of the plant such as tanks, pumps, heat exchangers, piping and others, being designed for cleaning in-place and sterilization.

Check Your Progress 3

1) Define Yoghurt.

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2) Write down the types of yoghurt manufactured.

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3) Give International standards for types of yoghurt (FAO/WHO).

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4) Give the flow diagram of manufacture of set yoghurt.

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5) Write down the manufacture of stirred yoghurt.

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6) Write down the modern process lines of yoghurt.

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2.7 LET US SUM UP

Fermented milks have been produced and consumed since ancient times. The exact origin(s) of the making of fermented milks is difficult to establish, but it could date from some 10-15 thousand years ago as the way of life of human beings changed from being food gatherer to food producer. Although the evolution of the fermentation process was strictly intuitive, the production of sour milk soon became the established pattern of preservation, and since early 1900s. Dahi has its popularity in Indian diet despite changing life styles and food habits with time. It is preferred over milk due to good taste high nutritive and therapeutic value and most importantly, enhanced keeping quality than milk in a tropical climate like ours. It is being consumed either as plain, sweetened or salted and spiced product. At present several types of fermented milk products such as dahi, lassi, yoghurt, mishti dahi, shrikhand, etc. are being produced and marketed. The dietetic and prophylactic properties of fermented products and their healing effects in certain conditions were recognized by many people. As a result, the use of various types of fermented milks has found a wide application.

2.8 KEY WORDS

Coagulants : Food grade organic or inorganic acids or acid whey which are used for coagulation of milk. Enzymes which are used for coagulation of milk during manufacture of cheese are also known as coagulants.

Homogenized : Milk which has been treated in such a maneer as to ensure break up of fat globules to such an extent that after 48 hours of quiescent storage no visible cream separation occurs on the milk. A homogenizer is used to achieve this effect in milk.

Microbe : A minute living entity, viral, bacterial, fungal or protozoan, too small to be seen without the aid of a microscope. Also called microorganism.

Microbiological safety : Food is microbiologically safe if it does not cause food born microbial intoxication (poisoning) or infection to the consumers.

Mishti doi : It is a sweet variety of dahi known as mishti doi, lal doi. It is popular in eastern India.

Probiotic foods : Probiotic foods contain cultures of live microorganisms, which when applied to human beings affect them beneficially by improving the intestinal microbial ecology.

Quarg : Fresh cheese, associated with Germany. Known as Tvorog in Eastern Europe. Represents a wide range of sour milk curd products.

Sanitization : Use of methods and materials to preserve or restore hygienic quality. In other words, to assume a hygienic product, sanitization must be maintained by the use of hygienic equipment by hygienic employees in hygienic surroundings.

Sanitizing : Destroying pathogenic organisms but does not ensure complete removal. Brings down their number within acceptable limits of hygiene. It is less expensive and less exacting and less time consuming than sterilization.

Spore : A vegetative or reproductive body of microscopic size produced by bacteria and fungi.

Starter culture : Microbial culture producing lactic acid, enzymes and other desired changes in milk and milk products.

Sterile : In bacteriology, free from all living organisms.

Thermoduric bacteria : Organisms with growth optimally at temperatures from 50-60^{o}C and are able to survive temperatures higher than 80^{o}C, but the dormant till favourable growth temperature

Aneja, R.P. Mathur, B.N., Chandarn, R.C. and Bajerjee, A.K. 2002. Technology of Indian milk products, Dairy India Publications, Delhi.

2.10 ANSWERS TO CHECK YOUR PROGRESS

Your answer should include the following points

Check Your Progress 1

1. i. Fermented milks are prepared from milk fermented with lactic acid bacteria.

   ii. It is preferred over milk due to good taste, high nutritive and therapeutic value and most importantly, enhanced keeping quality.

2. i. Dahi may be classified on the following basis:

   - Dahi for direct consumption.
   - Dahi for the production of chakka, shrikhand, lassi and butter milk.
   - Dahi for the production of desi butter and ghee.

   ii. According to consumption - dahi prepared from different types of milk such as whole, skim, toned, standard or special milk.

   iii. According to flavour – sweet, sour, sweetened and fruit dahi.

3. i. Selection of milk, treatment of milk including standardization, pasteurization.

   ii. Inoculation of milk with lactic acid bacteria (starter culture), packaging in suitable containers and incubation.

   iii. Cooling the product and storing under refrigeration.

4. i. Mishti dahi is a popular traditional sweetened fermented milk product.

   ii. In eastern parts of India, especially in West Bengal, Assam, Bihar and Orissa, the sweetened variety of dahi is known as misht doi, Lal dahi, or payodhi.

5. i. The composition of mishti dahi depend upon the type of milk, level of concentration, and fermentation conditions employed in its manufacture.

   ii. Three grades of mishti dahi are prepared using low-fat medium fat and high fat milk.

   iii. The fat, SNF, sugar and TS contents in low fat mishti dahi are 2-3, 13-14, 17-19, 32-35 percent respectively.

   iv. The fat, SNF, sugar and TS contents in medium fat mishti dahi are 4-5, 11-13, 17-18 and 32-36 percent, respectively.

   v. The fat, SNF, sugar and TS contents in high fat misti dahi are 8-9, 10-11, 17-18 and 35-38 percent, respectively.

6. i. Selection of good quality of milk, standardization of milk to 3.5% fat, 9.0% SNF.

   ii. Preheating of standardized milk homogenization of milk, and concentration to 1.44 fold.

   iii. Addition of sugar (approximately 14%), heating at 85^{o}C for 10 min.

iv. Cooling of mix, inoculation with 1% starter culture, filling in suitable containers and incubation at 40°C for 6-7 hrs.

v. Cooling and storage at 4-5°C.

Check Your Progress 2

1. i. Shrikhand is a semi-solid, sweetish-sour fermented milk product.

   ii. It is very close to flavoured quarg of Germany.

   iii. It is prepared by fermentation of milk with lactic acid bacteria, expulsion of whey from the curd, followed by mixing with sugar, flavouring and spices.

2. The standards prescribed for shrikhand by the BIS and under PFA are as follows:

	BIS	**PFA**
Total solids (per cent, by mass), minimum	58.0	58.0
Milk fat (in dry matter, per cent by mass), minimum	8.5	8.5
Milk protein (in dry matter, per cent by mass), minimum	10.5	10.5
Titratabel acidity (per cent lactic acid), maximum	1.4	1.4
Sucrose (in dry matter per cent by mass), maximum	72.5	72.5
Total ash (in dry matter per cent by mass), maximum	0.9	0.9
Coliform count, cfu/g, maximum	--	10.0
Yeast and mould count, cfu/g, maximum	--	50.0

3. i. The industrial method of shrikhand manufacture includes – heating of skim milk at 85°C/30 min, cooling to 30°C, addition of starter culture at the rate of 1.0-1.5%, incubation for 10-12 hours.

   ii. Drainage of whey from dahi by basket centrifuge.

   iii. Addition of cream, sugar, spices, flavourings, etc. and mixing thoroughly.

   iv. Packaging is suitable contains and storing under refrigeration.

4. i. Lassi is a ready to serve fermented milk beverage.

   ii. Good quality lassi should have a creamy consistency, smooth texture, glossy sheen and white colour with yellowish tinge.

   iii. It is flavoured either with sugar or salt and other condiments or spices.

5. i. The chemical composition of lassi depends on the type of milk, initial composition of milk, level of concentration of milk solids and the sugar level.

   ii. The proximate composition of lassi is as follows:

   Milk fat – 1.5 – 3.8%

   Milk TS – 9.0%

   Sugar – 13-20%

Sodium dihydrogen phosphate – 0.5% (Optional)

Acidity (minimum) – 0.7% LA

6. i. Industrial production of lassi includes ___ standardization of milk, pasteurization of milk, addition of starter cultures and incubation of mix.

   ii. Preparation of sugar syrup and blending with dahi.

   iii. Addition of flavour, condiments and spices.

   iv. Packaging of lassi in suitable packages and storing under refrigeration.

   v. Good quality lassi should have a creamy consistency, smooth texture, glossy sheen and white colour with yellowish tinge.

Check Your Progress 3

1. i. Yoghurt is a coagulum obtained by lactic acid fermentation of prescribed milk or milk products by the action of *Lactobacillus delbrueckii subsp. bulgaricus* and *streptococcus thermophilus*, the addition of additives is optional.

   ii. The final product should contain large quantities of the above microorganisms.

   iii. Yoghurt is characterized by a pungent fruity smell, sharp acid taste and firm body.

2. i. Commercial yoghurts are divided into three main categories, i.e. plain/ natural, fruit and flavoured.

   ii. These different types of yoghurt are manufactured in several forms such as set, stirred, liquid/drinking, frozen and dried/instant types.

3. i. Regular yoghurt should contain a minimum of 3.0 per cent fat and 8.2 per cent SNF.

   ii. Partly skimmed yoghurt should contain 0.5 to 3.0 per cent fat and a minimum of 8.2 per cent SNF.

   iii. Skimmed yoghurt should contain less than 0.5 per cent fat and a minimum of 8.2 per cent SNF.

4. i. Filtration, clarification and standardization of milk.

   ii. Incorporation of certain additives, preheating and homogenization of milk.

   iii. Heating to 90^{o}C/ 5 min and cooling to 43-45^{o}C.

   iv. Addition of flavouring, starter cultures (1-3%).

   v. Cooling and storage under refrigeration (4-5^{o}C).

5. i. From steps filtration to addition of starter culture are same as in case of set yoghurt.

   ii. Mixture is incubated in tanks and stirred and fruits (optional) are incorporated.

   iii. Cooling (20-30^{o}C), filling into containers and stored at 4-5^{o}C.

iv. Modern process lines for yoghurt are used in medium or large seek production.

v. Specially designed equipment are used for standardization of milk, concentration of milk.

vi. Milk is homogenized at 55-65^{o}C under a pressure of 2000-2500 psi.

vii. Milk is heated at 90^{o}C for 5 min or in UHT sterilizers (direct or indirect heating) at 135-145^{o}C for several seconds.

viii. Mechanically starter culture is added and filled in container, incubated and cooled.

ix. In case of stirred yoghurt the filling is done after incubation mechanically.

x. Processing equipment used in the manufacture of yoghurt, being designed for cleaning in place and sterilization.