

## Fermented Indigenous Indian Dairy Products: Standards, Nutrition, Technological Significance and Opportunities for its Processing

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Fermentation is used since time immemorial for preservation of food. Since its inception, human kind has been practicing fermentation of various food products based on milk, fruits and vegetables, meat products, cereal and legumes, etc. Milk based products constitute of a large portion of our diet primarily in the Asian countries specifically in the Indian subcontinent. India produces about 132 MT of milk every year. Almost 60% of this is converted in traditional products. Fermented dairy products like *Dahi* (curd), *Mishti Doi* (sweetened curd), *Shrikhand*, *Lassi* and *Chhach* or *Mohi* (buttermilk), etc. are consumed frequently by the India population. For long the production of these products was unorganised. Recent technological innovations, research and awareness amongst masses has caused improvement in this scenario. The current paper reviews these products in term of present research advancement in mechanization and standardization of these products to be produced on a large scale, improving its economic value and nutritional significance.

**Keywords:** Fermentation, Milk, Traditional products, Mechanization, Standardization.

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Fermentation is an economical and affordable technology which protects the food, enhances its nutritional value and helps in upgrading its sensory properties. It also assists the detoxification and elimination of objectionable factors present in unprocessed foods such as phytates, tannins and polyphenols (Gadaga *et al.*, 1999). Fermented milk products were initially developed by nomadic Asian cattle breeders. These products are manufactured by following the fermentation of milk by particular group of microorganisms, resulting in a decrease in pH and in successive coagulation of milk proteins

along with the microorganism which remains active as long as they do not experience heat treatment (Kabak and Dobson, 2011). Most of the fermented dairy products contain lactic acid bacteria (naturally present in milk), other bacteria as yeast and moulds are also included as well. In the procedure of making, starter cultures for fermented dairy products have been flourished (Wouters *et al.*, 2002). These products are the vital components of human diet in many parts of the world in the form of *curd*, *buttermilk*, *yogurt* (Yoghurt), *leben*, *cheese* and *acidophilus milk* (Nair and Prajapati, 2003). Fermented milk products are known for their great nutritional and health related properties including prevention of gastrointestinal infections, reduction of serum cholesterol levels and antimutagenic activity. These are also beneficial for ingestion by lactose intolerant human beings and the patients

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experiencing atherosclerosis (Shiby and Mishra, 2013). It can diminish the symptoms of atopy (Cross *et al.*, 2001). In India, fermented products such as *Dahi* (curd), *Mishti Doi* (sweetened curd), *Shrikhand*, *Lassi* and *Chhach* or *Mohi* (buttermilk), *Chhurpi*, *Somar*, *Philu* and *Shyow* are the known ethnic fermented products (Dewan and Tamang, 2007). This paper provides an insight into production, development and technological advances in manufacturing of the traditional fermented products of India.

### **Dahi**

*Dahi* is the local name of the curd (Dewan and Tamang, 2007). It is considered as traditional fermented milk product and also a functional food as it is nutritionally and therapeutically beneficial for human beings (Yadav *et al.*, 2007). It is consumed as such and also used as an intermediate product for many other products based on milk, such as buttermilk (*Chhach*) which is largely used as thirst quencher in summer? In eastern part of India *Dahi* is used as *Mishti Doi/Dahi* by adding sweetener such as jaggery, caramelized flavor and color to the *Dahi*. *Dahi* is prepared traditionally in almost every kitchen in India (Harun-Ur-Rashid *et al.*, 2006).

*Dahi* have live cultures that nurture therapeutic and health promoting properties along with nutritional benefits. The lactose in the milk is converted to lactic acid by the action of starter cultures and the lactic acid act as preservative for the milk and the low pH (4.5- 5.0) also inhibit the growth of harmful micro-organism, thus increasing the shelf life of the product (Sodini *et al.*, 2002).

The therapeutic value of *Dahi* is due to the fact that the concentration of lactic acid bacteria in the intestine obtained by the ingestion helps in digestion of food (Nahar *et al.*, 2007). Also, during fermentation the milk protein can be partially degraded by the action of bacterial proteases into peptides, possessing various health benefits. The availability of calcium is also increased from milk and thus increases the nutritional value of *Dahi*. In this process proteins are broken down into biopeptides, possessing various health benefits (Neilsen *et al.*, 2009).

*Dahi* is manufactured using single or mixed cultures of *Lactococcus lactis*, *Lactococcus cremoris*, *Lactococcus diacetylactis*, along with *Leuconostoc* species, a combination of acid and

flavor producing bacteria. These bacteria are responsible for imparting firm body, sweetness and a mild acidic flavor to the *Dahi* increasing its acceptability to the consumer. Flavour compounds such as diacetyl, imparts buttery flavor to *Dahi*, and is generated by some bacteria viz. *Leuconostoc* (Vinderola *et al.*, 2002).

*Dahi* produced on domestic levels has undefined cultures, thus, difference in texture and taste is often observed. With standardization of culture and production conditions a defined product of consistent quality (sensory and textural) can be achieved. Probiotic *Dahi* has also been manufactured by including secondary organism like *Streptococcus thermophilus* and *Lactobacillus acidophilus*. It is also influenced by the quality of milk, temperature, time and storage conditions (Garg and Jain, 1980; Coggins *et al.*, 2010).

The Prevention of Food Adulteration (PFA) Act defines *Dahi* as 'a semi solid product', obtained from pasteurized or boiled milk by souring using harmless lactic acid or other bacterial cultures. *Dahi* may contain additional cane sugar. It should have the same minimum percentage of fat and solid-not-fat (SNF) as the milk from which it has been prepared (De, 1980; Kumar and Mishra, 2004).

The Bureau of Indian standards (BIS) specification for fermented milk products are based on the types of culture used in their preparation (Anon, 1990). Mild *Dahi* is made from mesophilic *lactococci*. *Leuconostoc* may be used to adjust the flavor to the buttery flavor. Sour *Dahi* contains additional cultures from thermophilic group of bacteria. For manufacturing of *Dahi* different kinds of milk (i.e. cow, buffalo, goat) can be used. The composition of milk used to produce cultured dairy products is given in Table 1.

*Dahi* made from buffalo milk is thick in consistency due to high content of SNF in the buffalo milk. In traditional method of *Dahi* manufacturing, milk is first boiled in open kettle prior to fermentation that results in evaporation of moisture from milk making it more concentrated. In most of the cases increase in 10-15 percent in solids is observed, leading to thick body and desirable texture. It is recommended to make *Dahi* from a mixture containing 11-13 percent SNF. SNF of milk could be increased by addition of skim milk powder (SMP) or condensed skim milk.

This resulting increase in protein content keeps the product from wheying off and provides a custard-like consistency (De, 1980).

Fat content in *Dahi* can be standardized as per demand of the consumer ranging from full fat to no fat. Post fermentation heat treatment to *Dahi* can be helpful in extension of shelf life of the product but it destroys the bacterial cultures thus reduces the health beneficial properties. Thus, the codex mandates differentiate the labeling standards by live microorganisms and the heat treated products. Such products should be labeled such as "contains no active culture" for the consumer to make informed choice.

#### **Starter culture used in preparation of *Dahi***

Milk is the natural habitat of numerous lactic acid bacteria causing the natural souring of milk, held at bacterial growth temperature and appropriate length of time. Lactic acid bacteria can enter the milk from various sources such as air, utensils, milking equipment, milchers, cow feed etc. The soured milk gets undesirable texture and flavor, reducing its acceptability and contamination of the product from extrinsic factors can cause serious health hazards. However during the commercialization, starters containing specific genes, species and strains of cultures are used to generate desired flavor, body and texture characteristics (Chandan and Shahani, 1995).

A starter culture contains food grade microorganisms that on culturing in milk produce predictable attributes. Bacteria that grow at ambient temperature are called mesophilic bacteria whereas those grow at higher temperature are termed as thermophilic bacteria. Usually, mesophilic bacteria are used to prepare *Dahi*. Table 2 lists lactic acid bacteria used as starter cultures in the industries for manufacturing of various Indian dairy products

For commercial success of *Dahi*, the culture should meet the rapid acid development, typical *Dahi* flavor, body and texture, exopolysaccharide secreting strains to enhance viscosity of the product, scale up possibilities in various production conditions, including compatibility with variety and levels of ingredients used, fermentation time and temperatures, survival of culture viability during shelf life of *Dahi*, possessing desirable health and probiotic properties and exhibiting survival in the human gastrointestinal tract for certain health attributes, minimum acid production during

distribution and storage at 5 °C-10 °C until *Dahi* is consumed. Table 3 shows the characteristics of mesophilic cultures used in manufacturing of *Dahi*.

Microbiological specifications of these cultures suggests that counts of mesophilic lactic, yeast and moulds, coliform, anaerobic spore formers and salt tolerant micrococci should not exceed 10 cfu/g. *E. coli*, *S. faecium* and coagulase positive *staphylococci* should be less than 1 cfu/g. Culture should be free from pathogenic microorganism.

#### **Technology of *Dahi* manufacture**

*Dahi* is made from fat standardized milk. All ingredients should be of high quality and should be maintained the quality standard. While manufacturing *Dahi* at commercial level it is necessary to standardize and control the day to day product to meet consumer expectations and regulatory obligations. Since the total solids in cows and buffaloes milk ranges from 11 to 17 percent, therefore the cultured products from these milks vary in consistency from fluid to custard like. Casein also plays an important role in determining the texture of *Dahi*, casein coagulates on souring at isoelectric pH 4.6. The whey proteins are considerably denatured by heat treatment prior to culturing and as the denatured whey protein reacts with kappa casein (k-casein) as well as with other whey proteins, this ensures a better network formation and a firmer gel.

#### **Equipment used in *Dahi* manufacture**

A cultured milk plant should be specially designed to minimize the contamination of product with pathogenic micro-organisms. Even air is filtered in this regard. This type of plant has separate receiving section to receive, weigh and store the raw material. The culture room with control laboratory is completely separated from the processing section. In addition a dry storage area, a refrigerated storage area, a mix processing room, a fermentation room and a packaging room are maintained in the plant. A mix processing room containing equipments for standardization, milk separation, pasteurizing, incubation, heating and homogenization along with necessary pipelines, fittings, valves and controls is established (Bhattacharya *et al.*, 1972; De and De, 1999; Soukoilis *et al.*, 2007).

Milk is generally stored in silos. The inner layers of silos are made up of good quality of

stainless steel (Grade AISI 304) to avoid corrosion. The stainless steel is then covered with 125 mm of insulated materials which in turn is surrounded by outer shell of stainless steel or aluminum. In processing of *Dahi* and other fermented products the mixture is heat treated more severely (between 80 to 85 °C) than the conventional pasteurization methods. There are many beneficial effects of these heat treatments such as: (a) development of sterile medium that inhibit the growth of any undesirable microorganism; (b) removal of air from the medium to produce a more conductive medium for the growth of microaerophilic lactic cultures; (c) effecting thermal breakdown of milk constituents especially proteins that release peptones and sulfhydryl groups which provide nutrition and anaerobic conditions of the starter culture (d) it denatures and coagulate the milk protein which enhance the viscosity of the product (Bhattacharya *et al.*, 1972).

#### **Homogenization**

The homogenizer is a high pressure pump forcing the mix through extremely small orifice. Homogenization is generally conducted by applying pressure in two stages. The pressure in the first stage is of approximately 210 kg/cm<sup>2</sup> that reduce the average particle size of fat to approximately 4 microns of diameter. The second stage uses 35 kg/cm<sup>2</sup> pressure, used to break the clusters of fat globules separately. After homogenization all the fat globules of the milk has an average size below 1 micron. Homogenization of milk reduces the surface creaming in *Dahi* and ensures a better texture due to the fact that the increase in total surface area of the fat globules resulting from homogenization results in milk proteins (primarily casein) absorbing onto the surface of the fat globules. The homogenized fat globules thus act as active components of the protein network in the final *Dahi* (Bhattacharya *et al.*, 1972; Wu *et al.*, 2000).

#### **Fermentation**

Fermentation starts with the addition of culture in the milk. Addition of culture is done after cooling the milk to 37 °C. The inoculated milk is then packaged in separate cups with lids. After that cups are arranged in crates which are then transferred to hot room (37 °C) while the fermentation process proceeds. The pH of the milk in the cups should be regularly checked and when it

reaches 4.4-4.5, these crates are transferred to room with temperature 3-4 °C for proper setting. Figure 1 Shows the process flowchart for manufacture of *Dahi*.

*Dahi* normally contains no added sugar or flavor. Consumers can add sugar and flavor in *Dahi* according to their choice. *Dahi* can also be used for dressing of salads of fresh fruits and grated vegetables (De, 1980; Rautray and Mishra, 2011).

#### **Packaging and storage of *Dahi***

*Dahi* is generally packaged in polyethylene, polypropylene, polystyrene packaging material and plastic cups (Saint-Eve *et al.*, 2008) and it is recommended to store the packaged *Dahi* in between 1-4 °C to extend the shelf life. At 7 °C the shelf life of *Dahi* is estimated to be two to three weeks.

#### **Quality control for *Dahi* manufacture**

To make a product with the most desirable attributes the standards of fats, solids, viscosity, pH and organoleptic characteristics should be strictly followed. In the case of *Dahi* yeast is more potent contaminant than moulds or bacteria. Yeast and mould contamination may arise by contaminated starter cultures, packaging materials, and equipments. This could be avoided by following good sanitation processes. Organoleptic examination and microscopic examination of the starter could be helpful in eliminating the fungal contamination. Contaminated cultures should be avoided for product manufacturing. Lactic acid and some other metabolic products that are formed due to fermentation process inhibit the growth of most of the gram negative psychotropic bacteria (Anon, 1990).

#### ***Mishti Doi***

*Mishti Doi* is also called as payodhi or *lal Dahi* and is a popular product in the eastern parts of India, mostly West Bengal, where it is served with meal as a dessert. *Mishti Doi* is consumed on festive occasions and is considered auspicious item to serve while starting for journey or any important work. It is generally packaged in earthen pots (Tomasik, 1993; Tamang, 2016).

Traditionally, *Mishti Doi* is prepared from thickened milk with addition of palm jaggery, cane jaggery or sugar and then allowed to set by adding culture as in the case of *Dahi*. Cane sugar is the most common sweetener used in *Mishti Doi*. The process is usually carried out in earthen pot which

finally imparts a characteristic earthy flavor to the product and also absorbs the extra whey. It is served chilled (Ghosh and Rajorhia, 1990).

*Mishti Doi* is a fermented milk product with yellowish or creamish color with firm consistency, smooth texture and pleasant aroma (Raju and Pal, 2009). There were no available PFA standards for *Mishti Doi*. There are different grades of *Mishti Doi* available in the market such as low fat, medium fat and high fat.

#### Industrial production of *Mishti Doi*

Majority of the *Mishti Doi* prepared is produced on cottage scale. Due to lack of mechanization and standardization in the composition and quality of the raw materials and manufacturing techniques the market quality of the product varies considerably. However, attempts made to commercialize this product have met with little success (Goel, 1998; Raju and Pal, 2009).

A technology has been developed for manufacturing of *Mishti Doi* by the organized sectors. A wide range of sources (Table 4) of milk solids can be used in production of *Mishti Doi*. By combining all the ingredients in proper amount a well set *Mishti Doi* can be manufactured keeping in view the final composition and texture of the final product. Fresh, wholesome and good microbial and sensory quality ingredients are used, as the quality of raw material directly influences the quality of the final product. The acidity of *Mishti Doi* should not exceed 0.16%LA. The pH should be in the range of 5.2-5.4. It should be clot on boiling negative and free from off flavors (Goel, 1998).

Selection of starter culture is the most critical step in manufacturing of the product since it is responsible for flavor and texture development. Mixed cultures of *Streptococcus thermophilus* and *Lactobacillus spp.* are generally used since it gives superior quality of product and performs more reliably under variable conditions. Optimum performance of the *Mishti Doi* culture is expected to be at 42 °C. A good culture develops at 0.7 percent acidity within 6-8 hours with 1 percent inoculums (Chandan, 1982; Mandal, 2014).

*Mishti Doi* is colored and flavored with caramel. Caramel is produced by heating the sugar or also available commercially in viscous form. The pH of the caramel should be equal to the pH of the product that is around 5.0. Other ingredients like vanilla, cardamom and rose is used with or without nuts to make a wide range of *Mishti Doi* (Goel, 1998). Milk fat is the most important constituent of *Mishti Doi* (Table 5). It gives a characteristic top layer and a creamy rich flavor. SNF is responsible for giving smooth texture to the product (Ghosh and Rajorhia, 1990).

For industrial production of *Mishti Doi* milk and cream is heated in a vat with addition of SMP to increase the total solid. Sugar is also dry blended at this stage. Caramel is added at the rate 0.1 to 0.12 percent before heating of the mix. The mix is heated to 80-90 °C in a vat. It is necessary to have a filter in the process line to filter all suspended matters and the lumps. It has been observed that heating the mixture at 85 °C for 15 minutes gives the product better characteristics.

**Table 1.** Composition of milk used in the preparation of cultured dairy foods (g/100gm)

Mammals	Fat	Caseins	Whey proteins	Lactose	Ash	Total solids	Refernces
Cow	3.7-4.48	2.8-82.65	0.6-44.35	4.47-4.8	0.68-0.7	11.36-12.7	Longwah <i>et al.</i> (2017); Aneja <i>et al.</i> (2002)
Buffalo	6.58-7.4	3.2-82.65	0.6	4.11-4.8	0.67-0.8	11.2-17.2	Longwah <i>et al.</i> (2017); Ceballos <i>et al.</i> (2009); Aneja <i>et al.</i> (2002)
Goat	4.5-5.23	2.5-82.70	0.4-17.30	4.1	0.8	13.2-13.57	Ceballos <i>et al.</i> (2009); Aneja <i>et al.</i> (2002)
Sheep	4.9-7.4	4.6	0.9	4.8	0.94-1.0	16.22-19.3	Ceballos <i>et al.</i> (2009); Aneja <i>et al.</i> (2002); Hadipanayiotou (1995)
Mare	1.9	1.3	1.2	6.2	0.5	11.2	Aneja <i>et al.</i> (2002)
Sow	6.8	2.8	2.0	5.5	-	18.8	Aneja <i>et al.</i> (2002)

Table 2. Starter culture used in manufacture of fermented milk products

Product	Primary microorganism (s)	Secondary/optional microorganism(s)	Incubation temperatures and time	Major functions of culture	References
Dahi, shrikhand, mishti doi, lassi, buttermilk	<i>Lactococcus lactis</i> subsp. <i>Lactis</i> ,	<i>Leuconostoc lactis</i>	22 °C for 12-14 Hours	Acidity, flavour, aroma	Aneja <i>et al</i> (2002); Anon, (1990);
	<i>Lactococcus lactis</i> subsp. <i>Cremoris</i> ,	<i>Leuconostoc mesenteroides</i> subsp. <i>Cremoris</i>	or 37 °C for 5-8 hours		
Yoghurt	<i>Lactococcus lactis</i> subsp. <i>lactis</i> var <i>diaceplactis</i> ,	<i>Lactobacillus acidophilus</i> <i>Bifidobacterium longum/bifidum/infantis</i> <i>Lactibacillus casei/lactis/jugurti/helveticus</i>	43-45 °C/2.5 hours	Acidity, texture, aroma, flavour, probiotic	Cogginsetal.(2010) Aneja <i>et al</i> (2002); Anon, (1990); Cogginsetal.(2010)
	<i>Lactobacillus delbrueckii</i> subsp. <i>Bulgaricus</i>				
	<i>Lactobacillus delbrueckii</i> subsp. <i>bulgaricus</i>				
	<i>Streptococcus thermophilus</i>				

After that the mix is cooled to 40-45 °C in plate heat exchanger or circulating cold water around the vat (Ghosh and Rajorhia, 1990).

The culture is added with constant stirring at the rate 1 percent of the mixture. Inoculation is done at 43 °C so that it could be transferred to earthen cups easily. Lids are used onto the cups to make the cups airtight and prevent leakage of the product. Then the cups are arranged in crates in such a way that it causes minimum shaking and enough space is provided in between each cups and crates so that air could pass through them.

The mixture is then incubated at  $42 \pm 1$  °C for about 6-8 hours till the acidity develops to about 0.7 to 0.8 percent of lactic acid (Chandan, 1982; Mandal, 2014). Product is stored for incubation. The crates or trolleys used for arranging the cups are left undisturbed in the incubation room to prevent mechanical damage. Once the desired level of texture and acidity is obtained the product is shifted to cold store room of about 4 °C with minimum disturbance. The products at this stage are weak in body and texture. The storage temperature should be in between 3-5 °C if the product is required to be stored for longer period of time. But there may be problem of freezing at this temperature and cause hardness of the product and make the product more floppy. Thus special care should be taken during storage of the *Mishti Doi* to prevent freezing (Ghosh and Rajorhia, 1990).

*Mishti Doi* is arranged in crates and is transported in insulated box with cooling pads inside to maintain the temperature. The shelf life of *Mishti Doi* will be stored at 10 °C is 3 days, 5days at 4 °C.

Several types of *Mishti Doi* are available such as with added flavors (cardamom, vanilla, and butter scotch), fruits (mango, bananas, cherry) or grains and nuts (almond and pistachio). *Mishti Doi* manufactured without cream layer on the top reduces the tendency of wheying off and also gives the product smooth body texture. The effect of different bulking agents viz. maltodextrin, sorbitol and polydextrose, on the physico-chemical, sensory and textural properties of artificially sweetened *mishti Dahi* with aspartame and acesulfame K was studied by (Raju and Pal, 2011). Standard method with slight modification was followed for manufacturing *Mishti Doi*. It was found that maltodextrin is the best bulking agent as compared

to others. Maltodextrin increases the acidity, water activity, viscosity, hardness, adhesiveness and gumminess of the *mishiti Dahi*.

### Shrikhand

*Shrikhand* is a semi soft, sweetish sour, whole milk product prepared from fermented curd (Kulkarni *et al.*, 2006). The curd (*Dahi*) is partially strained through a cloth to remove the whey to produce a solid mass called *Chakka* (the basic ingredient for *Shrikhand*). *Chakka* is mixed with

the required amount of sugar to yield *Shrikhand* (Aneja *et al.*, 1977). The product thus obtained is garnished with nuts and condiments. *Shrikhand* is a very popular product and forms the part of meal on special and festive occasions particularly in the states of Gujarat and Maharashtra (Jain *et al.*, 1998). Like *Dahi*, it is also very refreshing product particularly in summer seasons.

Addition of artificial coloring or flavoring substances in *Shrikhand* is discouraged (Patel

**Table 3.** Attributes of typical mesophilic starters (lactic acid bacteria) used in *Dahi*, *Lassi*, *Shrikhand* and *Misti doi*

Characteristics	Lactococcus lactis subsp. Lactis	Lactococcus lactis subsp. Cremoris	Lactococcus lactis subsp. Lactis biovar diacetylactis	Leuconostoc mesenteroides subsp. Cremoris	Leuconostoc mesenteroides subsp. Dextransicum
Cell-shape and configuration	Cocci, pairs, short chains	Cocci, pairs, short/long chains	Cocci, pairs, short chains	Cocci, pairs, short/long chains	Cocci, pairs, chains
Catalase reaction	-	-	-	-	-
Growth temperature (°C)					
Optimum	28-31	22	28	20.25	20.25
Minimum	8-10	8-10	8-10	4-10	4-10
Maximum	40	37-39	40	37	37
Incubation temperature (°C)	21-30	22-30	22.28	22	22
Heat tolerance (60°C/30 minutes)	±	±	±	-	-
Lactic acid isomers	L(+)	L(+)	L(+)	D(-)	D(-)
Lactic acid produced in milk (%)	0.8-1.0	0.8-1.0	0.8-1.0	0.1-0.3	0.1-0.3
Acetic acid production (%)	-	-	-	0.2-0.4	0.2-0.4
Gas (CO <sub>2</sub> ) production	-	-	+	±	±
Proteolytic activity	+	+	+	±	±
Lypolytic activity	±	±	±	±	±
Citrate fermentation	-	—	+	+	+
Flavour/aroma	+	+	+++	+++	+++
Muco polysaccharide production	±	±	±	No dextran from sucrose	Dextran from sucrose
Hydrogen peroxide production	+	+	+	±	±
Alcohol production	±	±	±	±	±
Salt tolerance (% max)	4-6.5	4	4-6.5	6.5	6.5

Source: (Aneja *et al.*, 2002); (Coggins *et al.*, 2010); (Ceballos *et al.*, 2009)

**Table 4.** Sources of milk solids for *Mishiti doi*

Ingredients	Milk fat (%)	Milk SNF (%)	Sugar (Sucrose) (%)
Fresh cow/buffalo milk	4-6	8.5-9.5	-
Cream	30-40	5.4-6.3	-
Skimmed milk powder	0.5	95.5	-
Whole milk powder	26	70	-
Evaporated whole milk	8	18	-
Sweetened condensed milk	9.1	22	40-42
White butter	80	1	-

Source: Aneja *et al.* (2002)

and Chakraborty, 1988). According to PFA, *Shrikhand* is the product obtained from whole or skimmed milk *Chakka* to which milk fat is added (Upadhyay and Dave, 1977). It may contain fruit, nuts, sugar, cardamom, saffron and other condiments. It shall not contain any added coloring and artificial flavoring substances. It shall conform to the specifications given in table 6. The specified standards of Bureau of Indian Standards (BIS) for *Shrikhand*, under the Prevention of Food Adulteration (PFA) and under Food Safety and Standards Authority of India (FSSAI) are given in Table 6.

#### Technology of manufacture of *Shrikhand*

The manufacturing of *Shrikhand* consists of preparation of curd by adding starter culture to

milk, preparation of *Chhaka* by draining the whey and mixing of additional ingredients such as sugar and condiments to obtain desired product.

#### Traditional method of *Shrikhand* production

Traditionally cow or buffalo milk is heated to near boiling temperature and then cooled to 30-35 °C. It is then inoculated with lactic acid bacteria culture at the rate 0.5 to 1 percent of milk. Milk is then left at room temperature (30-35 °C) for 5-7 hours for setting of curd (Patel and Chakraborty, 1985a). When *Dahi* is firmly set, it is hung in muslin cloth overnight for drainage of whey. After 10-12 hours *Chakka* is obtained. It has been observed that there is 65 percent recovery of *Chakka* from milk depending on the composition of milk (Patel and Chakraborty, 1985b). Then the *Chakka* is mixed

**Table 5.** Approximate composition of *Misti doi*, standardized milk *Chakka* powder, standardized milk *Shrikhand* powder and *Lassi*

Characteristics In (%)	Low fat (%)	Mishit doi Medium fat (%)	High fat (%)	Standardized milk Chakka powder	Fssai standards	Standardized milk shrikhand powder	Lassi
Milk Total solids	32-35	32-36	35-38	96.18	d'' 30	96.08	9
Milk SNF	13-14	11-13	10-11	-	-	-	-
Milk Fat	2-3	4.5	8-9	36.48	d'' 33	19.82	1.5-3.8
Protein	-	44.96	d'' 30	24.12	-	-	-
Reducing sugar	-	11.53	-	6.64	-	-	-
Sugars or Sucrose	17-19	17-18	17-18	-	-	43.44	13-20
Ash	-	3.21	e'' 3.5	2.06	-	-	-
Acidity (%LA)	-	6.58	e'' 2.5	4.94	0.7 as lactic acid	-	-
Sodium di hydrogen phosphate	-	-	-	-	0.5	-	-
Low methoxy pectin	-	-	-	-	0.5	-	-

Source: (Aneja et al., 2002); (FSSAI, 2010)

**Table 6.** Specific standards for *Shrikhand* given by BIS, PFA and FSSAI

Constituent	BIS	PFA	FSSAI
Total solids (percent, by mass), minimum	58.0	58.0	≤58
Milk fat (in dry matter, percent by mass), minimum	8.5	8.5	≤ 8.5
Milk protein (in dry matter, percent by mass), minimum	10.5	10.5	≤ 9
Titrateable acidity (percent lactic acid)	1.4	1.4	≥ 1.4
Sucrose (in dry matter percent by mass), maximum	72.5	72.5	≤ 8.5
Total ash (in dry matter percent by mass), maximum	0.9	0.9	≥ 0.9
Coliform count, cfu/g, maximum	-	10.0	-
Yeasts and mould count, cfu/g, maximum	-	50.0	-

Source: (Aneja et al., 2002); (FSSAI, 2010)

with required amount of sugar (usually 50-100 percent of *Chakka* weight), condiments and other herbs. Commonly used spices or condiments are cardamom, saffron, cream, *Charoli*, (*Buchanania lanzan* is a tree which produces the seeds known as *Charoli* also called *Chironji*. These seeds are used as a cooking spice primarily in India. Charoli are tiny almond-flavoured dried seeds of a bush. After the hard shell is cracked, the stubby seed within is as soft as a pine nut, almonds, nutmeg, cashew nut, mango pulp, raisins and seasonal fruits (Bhattacharya *et al.*, 1971). About 1.5-2 kg of *Shrikhand* is obtained from 1 kg of *Chakka* (Sharma, 1998). *Shrikhand* is served chilled. The flowchart for manufacture of *shirkhand* is shown in Figure 2. In Gujarat, people prefer sweetened *Shrikhand* while in Maharashtra, salty or sour *Shrikhand* is preferred (Jain *et al.*, 1998).

**Mechanization of manufacturing of *Shrikhand***

A fully mechanized and continuous process has been developed for manufacturing of *Shrikhand* (Patel, 1997). The first modern plant for manufacturing of *Shrikhand* was established

at Baroda District Cooperative Milk producers Union Ltd. (Sagun unit) in Gujarat in 1980s under the brand name of Sagun and Amul. The industrial production involves the following steps:

*Preparation of curd:* Skim milk with 9% SNF, 0.05% fat is heated to near about its boiling temperature and then cooled to 30-35 °C (Patel and Chakraborty, 1985c; Singh *et al.*, 2014). Then *Dahi* culture at the rate 0.5-1% is added with constant stirring. After 8 hours of incubation the required acidity (0.8-1%) is achieved. The well set curd can be used for *Chakka* manufacturing. The *Dahi* used for preparation of *Shrikhand* is inoculated with mixed culture containing *Lactococcus lactis subsp. lactis*, *Lactococcus lactis subsp. diaacetylactis/Leuconostoc*, *Lactococcus lactis subsp. cremoris* in equal amounts (Chandan, 1982; Jagannath *et al.*, 2000)

*Chakka* is manufactured by draining the whey from curd. Drainage of whey from curd is

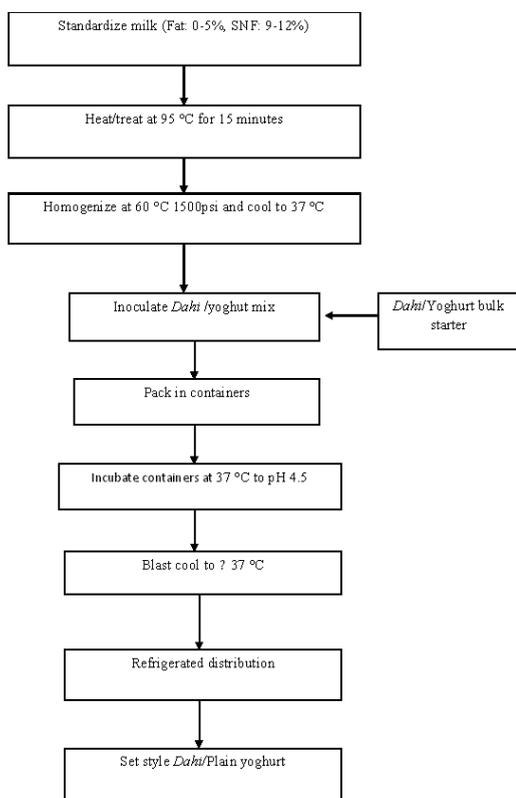


Fig. 1. Flowchart for the manufacture of *Dahi*

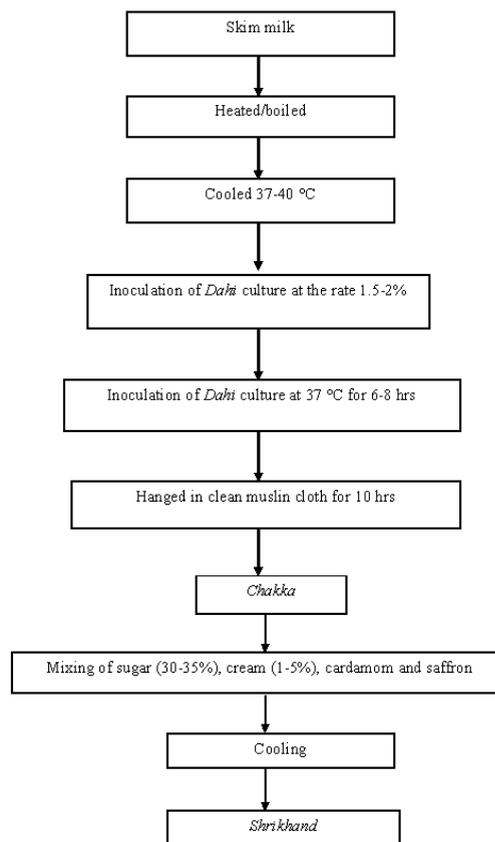


Fig. 2. Flowchart for manufacture of *Shrikhand*

done mechanically, using either a basket centrifuge at 1100 rpm or a quarg separator.

To mix the ingredients, planetary mixers of capacity of only 40 kg/batch were earlier used. However, now scraped surface heat exchangers are preferred over traditional mixers since this have the capacity of mixing of more than 500 kg per minute. These types of mixers in combination of two or three can be used in a continuous production system (Aneja and Vyas, 1983a).

*Shrikhand* is prepared by adding sugar and other desired ingredients with *Chakka* (Aneja and Vyas, 1983b). Sugar is added at the rate 50-100% of *Chakka* weight and mixed in scraped

surface heat exchanger (SSHE). Some amount of cream is also added to attain the final fat in the product to 8.5% on dry matter basis (Patel, 1997). The titratable acidity should be in the range of 1.10 to 1.40% LA. Herbal *Shrikhand* has been manufactured by adding water extract of *Brahmi* and *Ashwagandha* (*Brahmi* and *Ashwagandha* are Indian origin herbs that have large amount of antioxidant and polyphenolic components. *Brahmi* have memory enhancing properties while *Ashwagandha* have immunomodulatory, anticancerous and health promoting benefits) in *Chakka* with other ingredients that posses many antioxidant properties and different medicinal properties such as immunostimulatory, memory enhancing and anti hypertensive properties (Prasad, 2011). Guava pulp enriched *Shrikhand* has been manufactured by Kumar (2011), to increase the amount of vitamin C in the *Shrikhand*. This product has been found to be organoleptically acceptable. The product was slightly creamy in color than the conventional *Shrikhand*. For packaging of *Shrikhand* generally preformed polystyrene cups are used (Patel and Chakraborty, 1985b).

The shelf life of *Shrikhand* depends on the temperature and initial microbial load of the raw materials (Sharma and Zariwala, 1980). At ambient temperature i.e. at 30 °C it gets spoiled within 2-3 days. But under refrigerated condition (4 °C) it may be kept for 40 days. *Shrikhand* is stored at -18 to -20 °C that enhances the shelf life of the product for six months (Aneja and Vyas, 1987).

#### Physico-chemical properties of *Shrikhand*

Different manufacturers make *Shrikhand* according to the desire of their consumers. There is a little bit variation in the chemical and physical properties of *Shrikhand* that is manufactured in Gujarat and Maharashtra (Jain *et al.*, 1998). Variations have been found in *Shrikhand* that is available in the market under different brand

#### *Chakka* powder

For preparation of *Chakka* powder (Figure 3), whey is first of all removed from *Dahi* and then *Dahi* is ground in a colloid mill to obtain slurry with smooth and uniform consistency. The slurry is then heated to 38 °C followed by homogenization at a pressure of 100 kg/cm<sup>2</sup>. Finally, the slurry is passed through a spray drier with inlet temperature 185 °C and outlet temperature 85 °C to obtain *Chakka* powder (De and Patel, 1989). *Chakka*

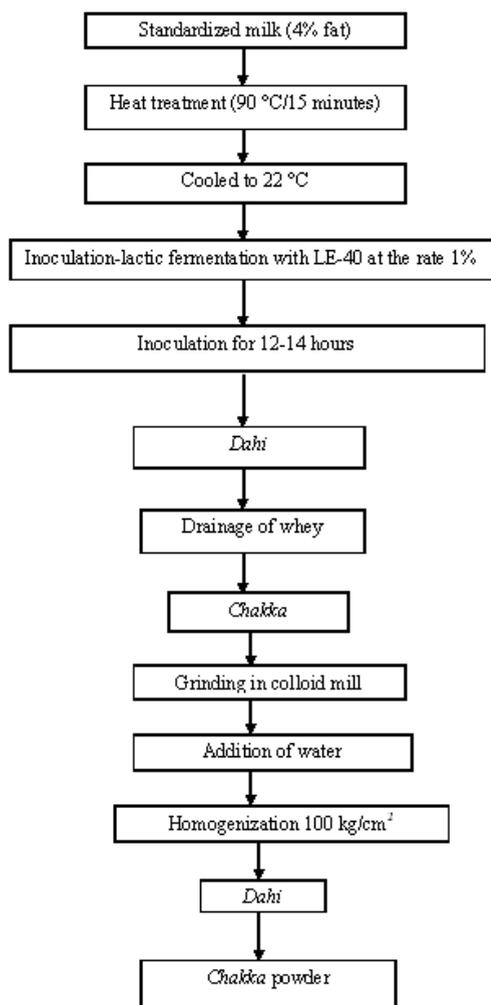


Fig. 3. Flowchart for the manufacture of standardized milk *Chakka* powder

taken from wholemilk is considered as the superior powder according to its consistency and aroma for incorporation in *Shrikhand*. The proximate composition of *Chakka* and *Shrikhand* powder is given in Table 5.

**Lassi**

*Lassi* is the local name of buttermilk. *Lassi* also called stirred *Dahi*, is a refreshing summer

beverage, mainly popular in north India. *Lassi* is white to creamy white in color, liquid viscous, with sweet taste, rich aroma to and slightly acidic. Depending upon the consumer preference *Lassi* can be either flavored with salt or sugar and other condiments or spices. *Lassi* is manufactured using pasteurized milk cultured with flavor producing culture microorganisms (Aneja et al., 1989).

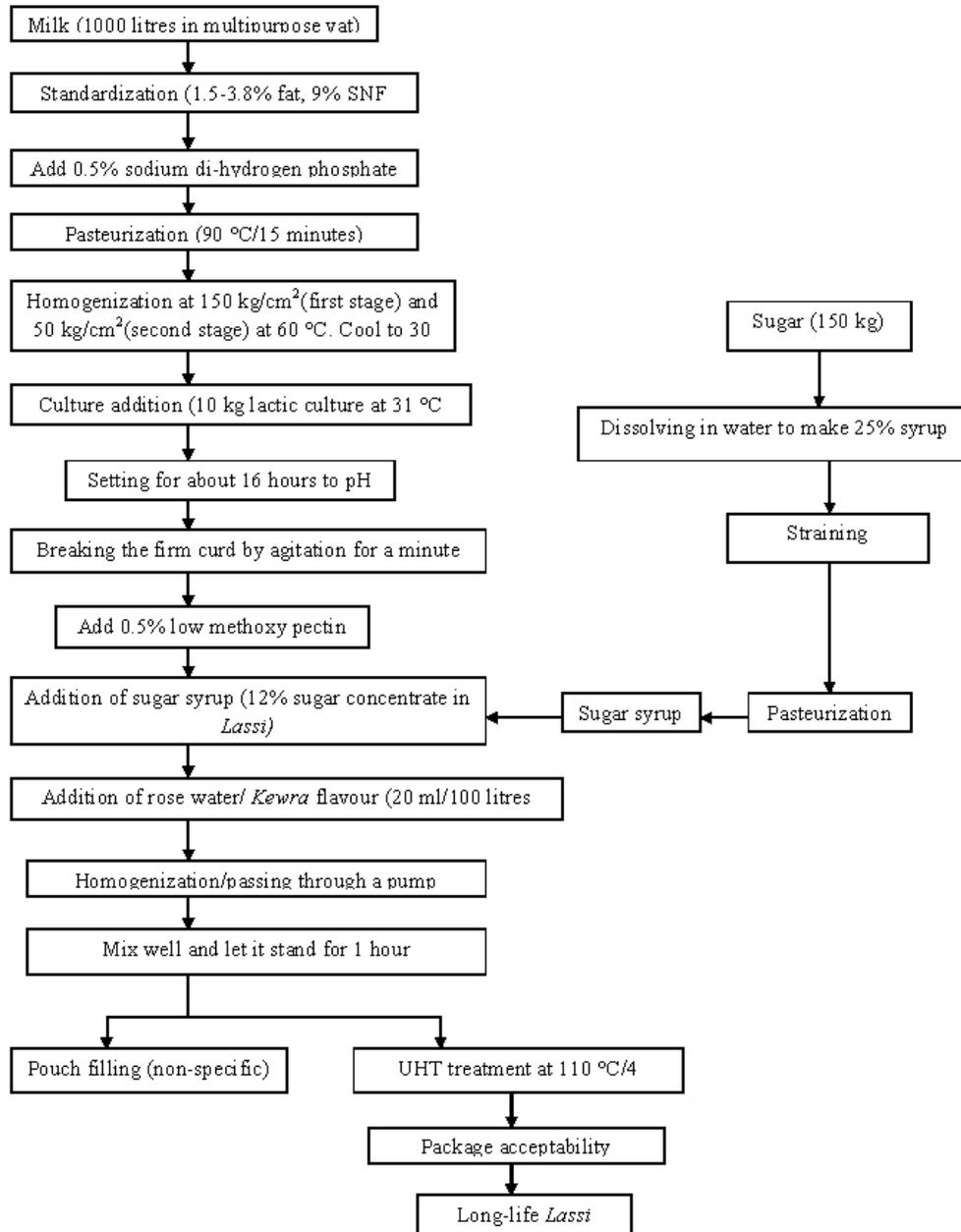


Fig. 4. Flowchart for mechanized production of *Lassi*

The phospholipids rich fraction obtained as by-product during churning of *Dahi* while making of *makkhan* (fresh butter), may also be termed as *Lassi*. *Lassi* is originally a product of rural India and was earlier was only produced at cottage scale. However, commercial production of this product is now established. Salted *Lassi* is marketed in many parts of the country. Commercially available *Lassi* can be aseptically packaged in milk cartons/sachets/UHT cartons (Ramana, 1994; Antunes *et al.*, 2007).

#### Technology for manufacture of *Lassi*

Newer technologies have been incorporated in the manufacturing of *Lassi*. Pasteurization, homogenization and culturing system are the steps that are taken into the manufacturing processes (Tiwari, 1998). Traditionally *Lassi* was manufactured by stirring *Dahi* with small amount of water. Other additives in *Lassi* are dependent on the local areas and individual preferences. In northern part of India *Lassi* is mixed with sugar while in southern part of the country salt along with other condiments such as crushed ginger, green chillies and curry leaves can be admixed in *Lassi*. In the southern states of India *Lassi* is preferred less viscous as compared to northern parts and have a pleasant aroma. Commercially *Lassi* is prepared by churning *Dahi* mechanically and then adding sugar in the form of syrup. Syrup is added to improve the thickening of the *Lassi* and also eliminate the addition of water. To improve the texture, homogenization is applied. *Lassi* can be flavored with rose or *Kewara* (It is a shrub with fragrant flowers. They are used to extract perfume, aromatic oil (*Kewara* oil) and fragrant distillations. These are stimulant and antispasmodic and are used against headache and rheumatism. The flowers are also used to flavour food; *Kewara* essence is used in numerous Indian sweets like *rasogolla*, *petha* (candied gourd or winter squash), *rasmalai* and *burfi*, (especially in Rajasthan). Essence and then packaged in bottles or pouches and stored at refrigerated temperature. The process flowchart for manufacturing of *Lassi* is shown in Figure 4.

Under refrigerated condition the shelf life of *Lassi* can be enhanced. Further extension can be achieved by UHT processing after fermentation and aseptic packaging (Ramana, 1994). Industrial production of *Lassi* had made significant advancements through application of

UHT processing. Standardized milk (9-10% SNF, 0.5-1.0% milk fat) is heated at 85 °C for 30 minutes or 91 °C for 2.5-5 minutes and then suitable lactic acid culture is inoculated at 31 °C (Chandan and Shahani, 1995). It is then allowed to ferment by keeping the milk at 22 °C till its pH reduces to 4.5. Then the set curd is stirred broken with mechanical stirrer along with mixing of sugar syrup (30%). This gives 8-12% sugar concentration in the blend. For proper texture *Lassi* is homogenized at 13.7 Kpa and UHT processed at 135-145 °C for 1-5 seconds and then packaged aseptically employing suitable equipments (Ladkani *et al.*, 1993). The defects in the quality of *Lassi* are very much similar to that of *Dahi*. The approximate composition of *Lassi* is given in Table 5.

#### Mattha/Chhach

*Mattha* or *Chhach* are the synonyms of buttermilk, which is consumed in all parts of the country. It is a consumed as refreshing summer beverage. *Mattha* or *Chhach* is a byproduct obtained during manufacturing of *Makkhan* from *Dahi* during its churning. It is famous for its aroma and mildy sour taste which is developed during fermentation by mixed microflora preferably lactic acid bacteria (Anantakrishnan and Srinivasan, 1964). The curd is churned into thick buttermilk which is called *Moru* in Kerala. *Moru* is diluted with water to reduce the acidity and then flavored with salt. When crushed ginger, green chillies and curry leaves are sometimes added to buttermilk, called *Sambharaam* which is popular in southern part of the country (Achaya, 1998).

#### Technology for manufacture of *Chhach*

Initially, milk is boiled and then cooled to 37 °C and then inoculum is added at the rate 1.0-1.5% of the milk. It is then allowed to set for overnight at 22 °C. When milk is set, small amount of water is added and is stirred with small wooden stirrer with wooden impellers locally called “*Mathani*” driven circularly by a rope in ‘to and fro’ motion. The *Makkhan* thus obtained is collected as a result of regular beating at the top layer which is removed from time to time. When all the *Makkhan* is removed from the mixture, the residue could be consumed as *Mattha* or *Chhach* (Anantakrishnan and Srinivasan, 1964).

*Mattha* is a liquid product that is highly flavorful and highly acidic. It contains 6-7% milk solids and 1-2% fat. *Mattha* is also rich in protein

and lactose. The quality defects of *Mattha* are very similar to *Dahi* and *Lassi* (Achaya, 1998).

### CONCLUSION

Fermented dairy products have a special place in Indian diet. No meal in India is complete without a bowl of *Dahi*. Products such as *Dahi*, *Lassi*, *Shrikhand*, *Chhach* are consumed throughout the country on regular basis. Not much information of the quantity of production of these indigenous fermented products is available as these are produced in highly unorganized manner. Mechanized production of these products has been recently attempted and is successful to some extent. However, far most these products are still manufactured on household or cottage scale. It is necessary to utilize the surplus milk produce of India in a sensible manner and converting it into its fermented products is a possible solution.

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