



# Advances in Processing of Heat Desiccated Traditional Dairy Foods of Indian Sub-Continent and Their Marketing Potential

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## Abstract

Heat desiccated milk products have been traditionally produced in Indian sub-continent since ancient times. This sector is poised to have rapid expansion hopefully with the innovations in technology, equipment's for mechanized production, packaging and storage. In order to overcome the inherent disadvantages associated with the conventional methods for manufacturing process of these traditional heat desiccated dairy products like insufficient use of energy, poor hygiene and sanitation, non-uniform product quality, etc. attempts had been made to upgrade product formulation and to develop batch, semi-continuous and continuous process. With globalization of dairy trade focussing on quality and consumer satisfaction, process optimization and mechanization of the manufacturing process of these products is very challenging. However, process of production and formulations for several heat desiccated traditional milk products have been upgraded and optimized by mechanization of traditional processes. Packaging sector also plays a vital active role in increasing the shelf life and market potential of these products. Efforts have been made to review on the development and improvements made for process upgradation of heat desiccated traditional milk products manufactured in Indian sub-continent, newer packaging options and their market potential.

**Keywords:** Heat Desiccated; Mechanization; Traditional Milk Products; Traditional Processes

## Introduction

In India, about 50% of the total milk produced is converted into various traditional milk products [1,2]. These products account for 95% of all the milk products consumed [3]. Traditional dairy products could be classified into six categories based on the principle of manufacture like heat desiccated, fermented, heat and acid coagulated, clarified butter fat, frozen and products made with addition of cereals [4-6]. Amongst them heat desiccation technique is the most ancient technology used to process the milk and milk

products. Scriptures from the early Buddhist and the Jain period have documented sweets made from head-desiccated milk such as sihakesara and morandeka. These have been used as desserts at the end of meals. Lord Buddha allowed his followers to take sweets as a portable ration for journeys on routes where it was difficult to get foodstuffs. In the Maurya Period (268-233 BC), sweets were prepared from concentrated milk and honey or jaggery. A variety of milk sweets have been described in the post Gupta period (750-1200 AD) literature also [7]. Pal [8] reviewed the technological advances in the manufacture of heat desiccated traditional Indian milk products. These products are rich in nutrition and also provide vital calories. Gross composition of some of the major heat desiccated dairy products is presented in Table 1.

Product	Milk source	Moisture	Fat	Protein	Lactose	Sucrose	Minerals	Reference
Khoa	Cow	30.40	22.20	18.80	24.90	-	3.70	[4]
	Buffalo	32.00	24.20	18.30	22.00	-	3.50	[4]
Rabri	Buffalo	49.80	15.50	9.50	11.30	12.00	2.00	[9]
Khurchan	Buffalo	27.90	23.60	15.40	14.9	15.20	3.00	[10]
Basundi	Cow	52.51	10.60	7.85	10.81	15.97	1.38	[11]
	Buffalo	52.98	11.45	10.11	11.11	12.50	1.80	[12]
Peda	Buffalo	14.36	19.31	15.34	15.25	33.27	2.47	[7]
Milk cake	Buffalo	16.80	21.30	11.40	7.70	40.50	2.30	[13]

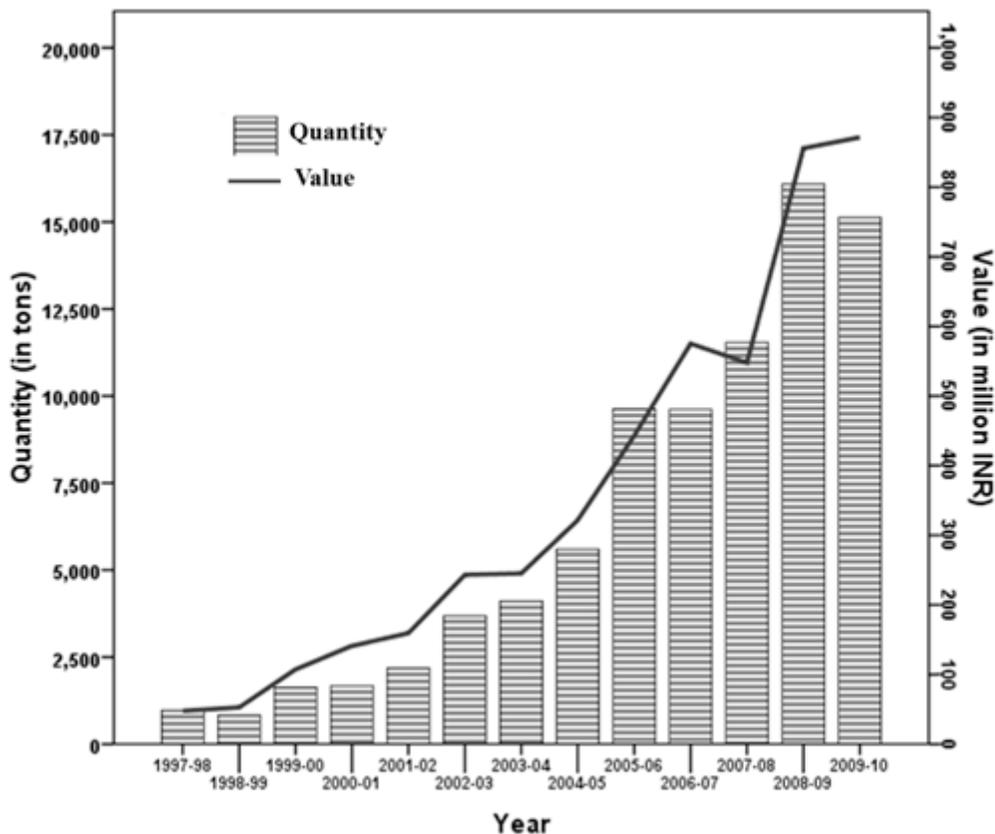
**Table 1:** Gross composition (%) of some heat desiccated traditional milk products.

The production of traditional milk products presents unique opportunity to the organised dairy sector as they have a huge mass appeal and the market for these products far exceeds that of western dairy products. The consumption of traditional dairy products is growing at an annual growth rate of more than 20%, but for the western dairy products the growth rates are relatively much lower (5-10%) [14]. While the western dairy products (with the exception of malted milk and milk chocolates) add about 50% value to milk, the traditional Indian dairy products add about 200% value to milk [15]. Further, the raw material costs of certain Indian traditional dairy products viz. shrikhand, rasogolla, gulabjamun, khoa-based sweets (peda, burfi, kalakand), sandesh and paneer is 29, 33, 34, 35 and 65% of the selling price, respectively. For the western dairy products, comparative costs are relatively much higher varying from 70-80% [14]. Significant headway has already been made in the industrial production of some traditional sweets such as gulabjamun, peda and burfi. The market size of ethnic milk products (Table 2) in India alone is estimated at more than 1000 billion INR with an annual growth estimated at 50 billion INR [16]. This development is no less than a revolution in the production and marketing of all time popular traditional milk products that were hitherto the exclusive preserve of traditional halwais (sweetmeat makers) on a much smaller scale.

Type of products	End products	Estimated market size (in billion Indian Rupees)
Chhana- based sweets	Rasogolla, sandesh, pantooa, rasomalai, cham-cham, channa murki, rajbhog, chhana podo, etc.	520
Khoa-based sweets	Kulfi, rabri, basundi, burfi, peda, gulabjamun, kalakand, khurchan, dharwad peda, kunda, etc.	
Paneer (Indian cottage cheese)		20
Fat-rich products	Ghee and makkhan	310
Fermented dairy products	Dahi, misti dahi, lassi, chhach/mattha, shrikhand, etc.	180
(Source: Gupta [3])		

**Table 2:** Market size of traditional dairy products.

Cutting across different regions of the Indian sub-continent, a number of heat desiccated milk confections are quite popular. These products are based on khoa/mawa, which is used as base material for sweets such as gulabjamun, kalajamun, burfi, kalakand, milk cake, peda, rabri, khurchan, basundi, pantua, kunda and lalmohan. Confections like bal mithai, phirni, Kunthalgiri pedha, malaipoori, lal peda, Dharwad peda and thirattupal are region-specific locally available sweets in different parts of India which are preferred by people for their characteristic taste and texture. A major market for Indian milk-based sweets is developing overseas. The Indian diaspora presents an exciting avenue for globalization of sweetmeats [1,17]. In North America alone, this market is estimated at US \$ 500 million [15]. The export of ethnic sweets from India mainly khoa- and chhana-based sweetmeats during the last decade is given in Figure 1.



**Figure 1:** Export of sweets (mostly khoa- and chhana-based) from India during 1997-98 and 2009-10 (Data source: Directorate General of Foreign Trade, India, 2010).

## Khoa

Khoa, the principal heat desiccated dairy product, is used as a base material for a huge variety of sweet delicacies. It is also called as *khoya*, *kava* or *mawa*. Its exact origin is not known but it has been prepared for centuries in Indian sub-continent as the base material for milk-based confections by milk traders and halwais. According to the Food Safety and Standards (Food Products Standards and Food Additives) Regulations [18] of India, *khoya* by whatever variety of names it is sold, means the product obtained from cow or buffalo or goat or sheep milk or milk solids or a combination thereof by rapid drying. The milk fat content shall not be less than 30 percent on dry weight basis of finished product. It may contain citric acid not more than 0.1 percent by weight. It shall be free from added starch, added sugar and added colouring matter. Khoa has a uniform whitish colour with just a tinge of brown, a slightly oily or granular texture, and a rich nutty flavour which is associated with a mildly cooked and sweet taste due to the high concentration of lactose. About 600,000 metric

tons of khoa is produced annually in India which utilize 7% of total milk production [19]. Nearly 36% of India's total khoa production takes place in Uttar Pradesh. The traditional trade usually pays for milk on the basis of the yield of khoa (with 28% moisture). The quality of khoa produced from buffalo milk is superior to khoa produced from cow milk because khoa from cow milk results in moist surface, salty taste with sticky and sandy texture which is not considered suitable for the preparation of sweetmeats [20]. Also, buffalo milk results in higher yield of khoa. Cow milk usually yields 17-19% of khoa by weight. The yield from buffalo milk is reported to be 21-23% by weight [5]. Emulsifying capacity of buffalo milk fat is higher due to the presence of larger proportion of butyric acid-containing triglycerides and release of more free fat compared to cow milk which may be responsible for smooth and mellow texture of khoa [21].

Khoa is classified by the Bureau of Indian Standards into three major types depending upon the specific end uses i.e. pindi, danedar and dhap [22]. Milk of high acidity produces a granular

khoa known as danedar type. Pindi khoa is characterized as a circular ball of a hemispherical pat with smooth and homogenous body and texture and free from burnt particles as well as any browning defects. It is most suitable for making peda. Danedar khoa is characterized by its granular texture and uneven body. The size of grains depends upon the amount of coagulant added and the quality of milk used. This type of khoa is used as a base for the preparation of kalakand, cakes and pastries where granulation is valued to a great extent. Dhap khoa is characterized by loose and sticky body and smooth texture. It contains less than 60 percent by mass total solids and higher moisture content than pindi and danedar types. Dhap khoa is preferred for the preparation of gulabjamun as it forms uniform balls with desired rheological qualities after frying and soaking in sugar syrup.

### **Standardization of Milk for Khoa Making**

Buffalo milk is preferred for khoa making because it yields a whiter product with a soft, loose body and a smooth granular texture which makes it suitable for the preparation of high-grade khoa sweets. A minimum of 5.5% milk fat level in buffalo milk is essential to meet the FSSAI [23] minimum fat requirements and to obtain a desirable body and texture in khoa. Lower levels of fat result in undesirable hard body and coarse texture [5]. Beniwal et al. [23] standardized the buffalo milk for the production of khoa through a semi-automatic machine. Based on physico-chemical parameters and sensory evaluation, fat/SNF (solids not fat) ratio of 0.611 in milk was found to be the most suitable for preparation of khoa [23].

### **Technological Innovations in Khoa Making**

The prehistoric process of khoa making in mild steel shallow open pans on open flame of fire with vigorous mixing using a wooden or steel ladle has been scaled up by different semi-continuous and continuous machines which are used in places where the quantity of milk is sufficiently large for khoa making. The first model of continuous khoa making machine of 50 litres per hour capacity was developed by Banerjee et al. [24]. The process involved a steam jacketed cylinder fitted with rotary scrapers followed by final concentration in an open cascading steam jacketed pan with mechanical scrapping agitators. Subsequently, the process was standardized with several modifications suggested by [25].

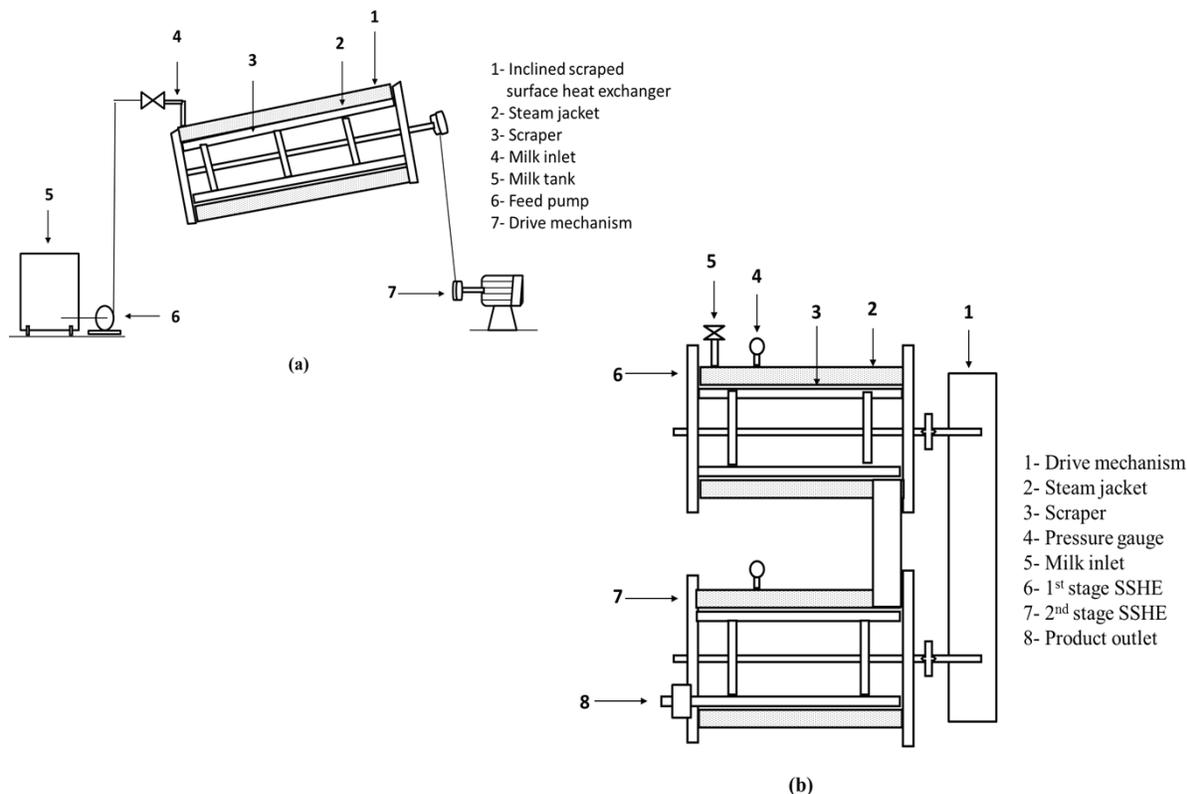
The equipment for the production of khoa under rural conditions was developed by Sawhney and Kumar [26] providing a semi-jacketed, shallow open pan and using a swinging hanger type scraper for stirring during the desiccation process. The 2/3<sup>rd</sup> of pan is filled with water placed over the furnace. Steam generated inside the jacket, is regulated by a safety valve to control the pressure and temperature. Steam pressure inside the jacket varies from 0 to 4 kg/cm<sup>2</sup>. On the basis of principle of scrapped surface heat exchanger, more [27] designed a semi-mechanized batch type process for khoa manufacturing which consisted of jacketed drum with vapour exhaust and scrapper assembly. Christie and Shah [28-30] have extensively worked on mechanization of khoa using steam jacketed cylinder with several modifications.

An Inclined Scraped Surface Heat Exchanger (ISSHE) was developed for continuous khoa-making by National Dairy Development Board (NDDB), Anand, India [31]. The plant comprises of a balance tank, a positive displacement pump and an ISSHE. Milk concentrate of about 42-45% total solids, is used as feed. The inclination of ISSHE permits the formation of a pool of vigorously boiling milk important to the formation of khoa (Figure 2a). Khoa prepared by ISSHE is similar to the conventional product from sensory point of view and also maintains compositional and rheological uniformity during continuous operation. A thin film scrapped surface heat exchanger (TSSHE) was also developed by Dodeja et al. [32] at National Dairy Research Institute (NDRI), Karnal, India for the continuous manufacture of khoa. TSSHE unit consisted of two mild steel SSHE arranged in cascade fashion (Figure 2b). The milk is concentrated to 40-45% total solids in first SSHE and finally to khoa in second SSHE. Unlike in ISSHE, the feed for this unit is buffalo milk and thus rendering it suitable for small and large organised manufacturers and entrepreneurs. Dodeja and Deep [33] mechanized the process for the manufacture of danedar khoa using three stage SSHE (Figure 3). Bhadania et al. [34] studied the energy requirements of SSHE during manufacture of khoa and concluded that three-stage SSHE could be successfully used for the continuous manufacture of khoa. The steam requirement for the manufacture of khoa varies between 1.28 - 1.62 kg per kg of water evaporated under various operating conditions of the SSHE. The quality of khoa prepared from different mechanized systems is given in Table 3.

Characteristics	ISSHE	Conical Vat	Contherm-convap	Roller process
Total Solids (%)	65.63	63.14	63.76	70.96
Fat (%)	21.97	21.15	21.50	27.75
Free fat (% of total fat)	35.00	43.53	58.37	51.15
Acidity (%)	0.53	0.54	0.61	0.58
Colour (Lovibond tintometer readings)	1.61y	1.68y + 0.3R	2.03y + 0.5R	1.5y
Hardness (mN)	47.46	58.09	52.01	89.67
Cohesiveness	0.512	0.450	0.434	0.406
Adhesiveness (mN)	0.268	0.662	0.757	0.465
Springiness (mN)	4.80	7.33	8.00	6.16
Gumminess (mN)	29.29	26.04	22.57	36.40
Chewiness (mm.mN)	116.42	191.20	181.06	223.97

(Source: Rajorhia et al. [35])

Table 3: Quality of khoa prepared from different mechanized systems.



Figures 2(a-b): Mechanized process for the manufacture of khoa. Schematic representation of (a) inclined scraped surface heat exchanger (b) Two-stage scraped surface heat exchanger (Source: Minz and Singh [36]).

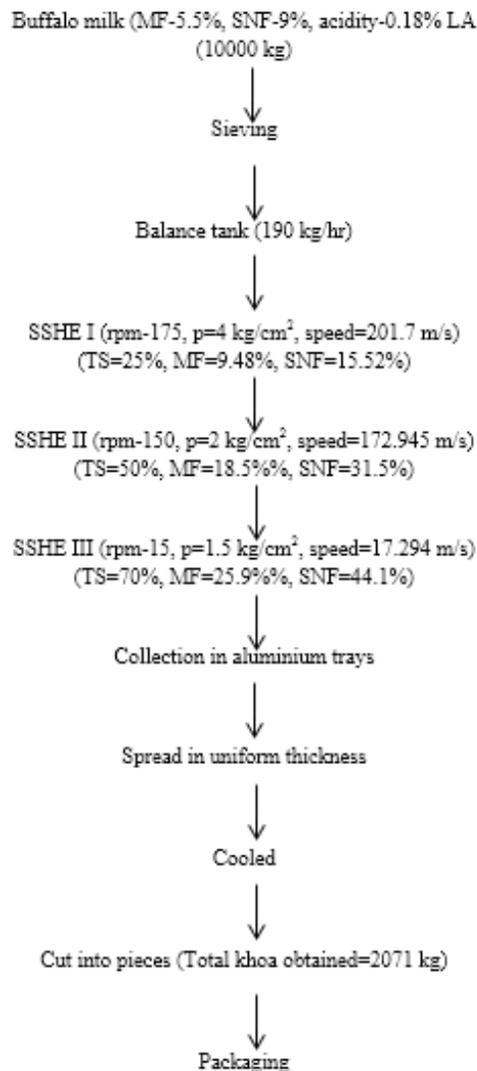


Figure 3: Manufacture of danedar khoa using three stage SSHE [33].

### Alternative Techniques for Khoa Making

Alternative techniques have also been used for khoa production to assist in the development of mechanized processes. Singh and Rajorhia [37] studied the possibility of adopting a roller dryer for khoa production. The process was found to be highly energy-intensive and khoa obtained by this method was flaky, dry and completely lacked the desired consistency. Pal and Londhe [38] extensively reviewed the application of membrane technology for the production of traditional dairy products. The use of pre-concentrated milk has been suggested in several previously reviewed mechanized processes for the khoa production. Pre-concentration of cow milk, 2-fold [39] and buffalo milk 1.5-fold [40] using reverse osmosis technique followed by heat desiccation in a steam jacketed open pan has been successfully demonstrated.

### Microbiology of Khoa

Khoa is a favourable medium for the growth of microbes on account of its nutritive value and moisture content. The unsatisfactory practices generally followed in its production, handling and storage in unorganized sector results in poor shelf life [41]. Although during manufacture of khoa, milk is subjected to drastic heat treatment, the aerobic spore formers are known to survive such heat treatment and may outnumber other types of micro-organisms, thereby suggesting that the survivors might multiply during subsequent storage. The possibility of contaminants gaining entry into these products during subsequent handling also cannot be ruled out [42].

Rajarajan et al. [43] studied the effect of antifungal agents on keeping quality of khoa. They treated the samples with natamycin (0.5%) and potassium sorbate (0.3%). It showed lower yeast and molds counts during storage at 30 and also at 5°C. Chavan and Kulkarni [44] made efforts to improve the microbiological quality of khoa by solar radiation and microwave heating. The application of microwave heating was observed to be quite superior in reducing the total bacterial count, Yeast and Mold Count (YMC) and spore count. It also showed very slow rate of increase during storage for a week. Use of solar radiation through convex lens showed promising results in reducing microbial counts and particularly more effectively on YMC.

A study was conducted to analyze bacterial contaminants/pathogens in khoa samples sold in Chambal region of Madhya Pradesh in India. A total of 50 samples of khoa were brought from different localities of Chambal region at random. Bacterial colony counts were also performed on these samples. *Staphylococcus* and *Streptococcus* species were the predominant isolates. The viable counts obtained ranged from  $1.3 \times 10^4$  to  $2.1 \times 10^6$  CFU/g. Contamination of khoa by pathogenic bacteria could be an important factor for gastrointestinal infections like food poisoning and food borne illness. Adequate consumer protection can be achieved by assessment of the microbiological data of the product [45]. Heat processing of milk at 63 or 73°C having 3.5-6.5% fat, eliminated all *Escherichia coli*. Under similar processing conditions, *Staph. aureus* was recovered, only when milk was heated at 63°C having 6.5% fat. Potassium sorbate (3000 ppm) appeared more effective in inhibiting the growth of selected yeast and molds in khoa at 7°C, compared to ascorbic acid (3000 ppm). Reducing the water activity ( $a_w$ ) of khoa from 0.97 to 0.93 did not appear to enhance the preservative effect. The reduction of *E. coli* or *Staph. aureus* in khoa during prolonged storage at 6-7°C, was less than one log cycle, regardless of  $a_w$  or preservative type. Survival of *Staph. aureus* in khoa appeared to be enhanced with a decrease in  $a_w$  [46].

A study was conducted to identify the incidence of different microorganisms in air and khoa samples collected from different sections of a khoa plant. *Penicillium citrinum* was found to be

predominantly present in both air (23.91%) and khoa samples (27.38%). The other molds encountered were *Geotricum candidum*, *Mucor racemosus*, *Aspergillus niger*, *Syncephalastrum oxysporum*, *Rhizopus stolonifer*, *Cladosporium cladosporioides*, *Absidia corymbifera* and *Pacilomyces variotti* [47].

## **Khoa Based Indigenous Products**

### **Burfi**

Burfi is the most popular khoa-based confection in Indian sub-continent. It is prepared by mixing different proportions of khoa and sugar along with some other ingredients i.e. dry fruits, fruit pulps, different cereals, pulses and their flours and flavouring materials. Traditionally, burfi is prepared by vigorous blending of khoa and sugar in open shallow kettle till a homogenous, smooth and fine grain mass appears and is transferred hot into a tray for cooling and setting. A variety of delicious burfi is available with varying proportions of ingredients, need and speciality. Kaju katli is one of the most common burfi available in market. A good quality burfi (plain) has white creamish to yellowish colour, soft body with very fine grains and smooth texture. Mango burfi was prepared by Shelke et al. [48] in which khoa was replaced up to 15% by mango pulp and the product was found to have higher sensory acceptability as compared to plain burfi. In another study, attempts were made to examine the suitability of pulses (Chana or Moong) for the preparation of buffalo burfi. Admixtures of different levels of khoa, pulses and sugar were tried. Burfi prepared from a mixture of buffalo milk khoa, chana dal and sugar in the ratio of 60:10:30 was found to be most suitable on the basis of sensory and chemical quality. The product was acceptable up to 21 days when stored under refrigerated condition [49].

Attempts were made to develop continuous method for burfi making in combination with khoa making system and burfi making unit [50]. Palit and Pal [51] also worked on mechanized production and shelf life of burfi. They used standardized buffalo milk (fat: SNF ratio of 1:1.5) with thin film scrapped surface heat exchanger and Stephen processing kettle for the production of burfi. Use of cardamom and potassium sorbate @ 0.1% each and vacuum packaging were tried for increasing the shelf life of burfi. The workers reported that in spite of slightly pasty texture; burfi prepared by mechanized process was highly acceptable with a shelf life of about 60 days at 30°C. A mechanized process for industrial production of burfi was successfully developed by NDDDB, Anand, India and installed at the Sugam Dairy, Baroda, India.

Burfi contains high amounts of fat (19.52%) and sugar (29.4%) which are major constraints to relish for obese, diabetic and people prone to heart diseases. With a view to overcome these constraints, Morlock and Prabha [52] used sucralose as high potency sweetener for developing dietetic burfi. The stability of sucralose in milk-based confection was validated under the usual

storage conditions at 5, 30, and 45°C for up to 28 days. Arora et al. [53] studied the textural and micro-structural properties of burfi made with various types of sweeteners such as saccharin, acesulfame-K, sucralose and aspartame. The recovery of aspartame studied by Arora et al. [54] using reverse phase High Performance Liquid Chromatography (HPLC) was reported to be 90-97%. Sensory score was the highest at a level of 0.065% of aspartame in milk (w/w) and had similar sweetness as of control burfi. The shelf life of burfi was also studied by Vijayalakshmi et al. [55] using different packaging materials under different atmospheric conditions such as normal packaging, vacuum packaging and use of a free-oxygen absorber (at 65% RH/27°C). Normal packaging even in barrier film did not effectively control microbial spoilage. Vacuum packing, although it retarded microbial growth, adversely affected the textural and sensory qualities. A free-oxygen absorber coupled with high-barrier materials like metallized films/foil laminates resulted in more than 45 days' shelf life for burfi.

Doda burfi, another burfi variant, is a traditional cereal-based milk confection. Traditionally, doda burfi is made by crushed wheat grains (sanmak), wheat flour, sugar and ghee in different proportions. The combination of lysine-rich milk protein with lysine-deficient cereals such as wheat delivers the synergistic effect, which imparts a high nutritional value to the product. Gajbhiye et al. [56] made attempts to standardize the doda burfi and further improve its properties by replacing sanmak by dried sprouted wheat grains. Admixtures of sprouted wheat gains (5, 7, and 9%) and sugar (7, 8, and 9%) at different levels were tried with wheat flour and ghee kept at constant level of 2% respectively. 7% of sprouted wheat grains and sugar each gave the most acceptable combination.

### **Gulabjamun**

Gulabjamun is another popular khoa-based confection in the Indian sub-continent including India, Pakistan, Nepal and Bangladesh. Traditionally, gulabjamun is made of dough consisting mainly of khoa and maida (refined wheat flour). Small balls made from this dough are given either round or cylindrical shape, and deep fat fried to gold to dark brown colour. Body of gulabjamun is soft and slightly spongy, free from lumps and hard central core. It has a uniform granular texture soaked in thick sugar syrup flavoured with cardamom seeds, rose water or saffron.

Traditional method of gulabjamun manufacture has been standardized by Ghosh et al. [57]. In this method, 300 g of dhap type khoa having 40-50% moisture, 100 g of flour and 3 g of baking powder are mixed, kneaded into uniform dough using sufficient amount of water. Dough is divided into small balls, and then deep fried in edible oil in an open shallow pan to a golden-brown colour. These fried balls are soaked in sugar syrup (62.5%) maintained at about 60°C for 2 h until it became soft and spongy. Recently, Renuka et al. [58] used Fructo-Oligosaccharides (FOS) and FOS-

sucrose blend over sucrose in gulabjamun syrups that indicated the potential of FOS as a low calorie and healthier alternative for sucrose in the preparation of gulabjamun. Dietetic filled milk khoa-based gulabjamun was prepared from milk with 3% vegetable oil and 8.5% SNF [59].

Joshi et al. [60] made attempts to statistically optimize the formulation and processing conditions of gulabjamun as an immense opportunity for the organized manufacturers in India to modernize and scale-up their production. Optimization of the formulation was carried out in terms of khoa:maida ratio (70:30-90:10), level of baking powder (0.2-1% of the khoa:maida mixture), frying time (7-11 min), sugar syrup concentration (50-70°Brix), temperature of sugar syrup (30-70°C) and soaking time (2-10 h). Mechanization for the manufacture of gulabjamun from khoa has been reported by Banerjee [61]. A study was undertaken to determine the efficacy of defatted soy flour mix levels in gulabjamun and to analyse its impact on the quality parameters. Soy flour was fortified at three levels (3.33, 6.66 and 9.99% w/w) to prepare different compositions of gulabjamuns by replacing wheat-flour in control sample. Appearance, colour, texture, flavour and overall acceptability of the gulabjamuns were reported to be improved with the addition of 3.33% soy flour and decreased thereafter with addition of more soy flour [62]. New technology for industrial production of gulabjamun has been developed using an assembly line system and is in operation at Sugam Dairy, Baroda, India. Gulabjamun mix powder, as a convenience formulation is also available in the market for a long time and is quite popular among the masses.

There was high correlation observed between kinetics of colour and textural parameters of gulabjamun. Frying-induced surface browning was reflected in a decreasing lightness value  $L^*$  as well as the ratio of yellow hue index  $b^*$  and red hue index  $a^*$ . Increase in hardness and firmness followed zero-order reaction kinetics whereas increase in stiffness followed first-order reaction kinetics.  $L^*$  alone could be used to predict the firmness of deep-fat fried gulabjamun balls [63]. A study was conducted by Rao et al. [64] to evaluate the effect of the concentration of sugar syrup used for dipping fried gulabjamun balls made from fresh and one month stored mix on volume expansion, hardness and colour of the resulting product. Temperature of diffusion did not have any effect on volume expansion. However, higher sugar syrup concentration resulted in decrease in volume expansion. Storage of gulabjamun mix powder led to softer gulabjamun whereas higher concentrations of sugar syrup resulted in increase in hardness. Temperature of diffusion did not have any bearing on hardness of the samples [64].

## Peda

Peda is also a khoa-based indigenous dairy product, popular throughout India. Several types of peda are produced in different

regions of the country with modifications in the process i.e. Doodh peda/ Mathura peda (Uttar Pradesh), Kunthalgiri peda (Maharashtra), Dharwad peda (Karnataka), lal peda (Eastern Uttar Pradesh) and bal mithai (popular in Uttarakhand, caramelized and coated with crystal sugar). Peda is generally prepared by mixing khoa and sugar in the ratio 3:1, the mixture is heated on gentle fire, stirred till the mixture attains a relatively firm texture. The content is mixed thoroughly and made into balls of 15-25 g size by rolling between the palms. The balls are flattened to give the disc shape. Dies and moulds may also be used to shape them [7,8]. Sometimes, nut and flavouring materials such as cardamom, saffron (Kesar peda) and cocoa may also be used along with permitted colours. Industrial method for manufacture of peda has been adopted by Sugam Dairy, Baroda. Khoa made in ISSHE is transferred to a planetary mixer and sugar @ of 30% of khoa, flavouring/ colouring ingredients, additives etc. are properly mixed. The peda mass is cooled to 4°C and forming/shaping of *peda* ball is done by Rheon shaping and forming machine.

Ray et al. [65] compared the chemical, microbiological and organoleptic quality of market and laboratory made peda (made from cow and buffalo milk). Variations in the samples were observed and laboratory made peda from buffalo milk was found to be superior to peda made from cow milk, as well as peda collected from the market. Narwade et al. [66] also studied the quality of market and laboratory made peda. Desale et al. [67] studied the effect of processing and compositional variables on the quality of peda and reported that stirring at 120 rpm of speed after the addition of sugar was found to be optimum to obtain good quality peda. Maximum sensory scores were obtained for the peda having a composition of 30% sugar, 15% moisture and 25% fat. Biradar et al. [68] reported a negative linear relationship between the logarithm of mold-free shelf-life and equilibrium relative humidity (ERH) at  $27 \pm 1^\circ\text{C}$  in the studied ERH range of 75-92%. Packaging in 100 and 300-gauge low density polyethylene (LDPE) pouches reduced weight loss, browning and Free Fatty Acid (FFA) development, and retarded deterioration of flavour, odour and acceptability of peda during storage. Peroxide value was not influenced by LDPE-packaging. LDPE-300 was more effective in controlling weight loss, browning and FFA formation as compared to LDPE-100. Film thickness, however, did not influence the organoleptic attributes significantly.

Among the available varieties of peda, brown peda is more popular and prepared throughout the country on a small scale. Brown peda is characterized by caramelized colour, highly cooked flavor and longer shelf-life. Depending on the area of consumption, it differs in the intensity of characteristic colour and flavour [69]. It is popular in Uttar Pradesh as Mathura peda, in Karnataka as Dharwad peda, and in Maharashtra as Mishra peda [70]. In almost all the types of brown peda, khoa is first cooked to brown colour in ghee (clarified butter) and then peda is prepared from it by blending

sugar and other additives such as cardamom. It is usually sold after wrapping in glossy-paper/paper-board which does not render perfect protection to the sample. Londhe et al. [71] studied the effect of conventional cardboard boxes, modified atmosphere and vacuum packaging techniques on the sensory, physico-chemical, textural, biochemical and microbiological quality of brown peda and reported that vacuum packaged brown peda could be best preserved up to 40 days at 30°C.

Another type of Peda especially popular in the Varanasi, Uttar Pradesh (India) is lal peda. It has a distinctive cooked taste and comparatively longer shelf life. Lal peda is produced on small scale by local sweetmeat makers. It is generally prepared from khoa (prepared from cow milk, buffalo milk or a combination of both) as a base material and sugar. Lal peda is characterised by its reddish-brown colour due to caramelization of sucrose during heat processing. Pandey et al. [72] prepared lal peda and the highest yield was reported for the product prepared from mixed milk with 60% sugar. Jha et al. [73] reported that when lal peda samples packed in paper boxes and stored at two different temperatures i.e. 4 and 37°C, there was a continuous loss of moisture at 37°C. Further, FFA and HMF contents increased during storage and these changes were reported to be temperature sensitive. On the basis of textural and sensory attributes, it was observed that lal peda samples were acceptable up to 31 and 9 days, at 4 and 37°C, respectively.

Londhe and Pal [74] studied the effect of preservatives on keeping quality of vacuum packaged brown peda during storage. Addition of butylated hydroxyl anisole (BHA) (@ 0.02% on fat basis) and the combination of BHA (@ 0.01% on fat basis) and potassium sorbate (@ 0.1% on the basis of total solids of peda) along with vacuum packaging was attempted to enhance the shelf life of brown peda. Brown peda balls were vacuum packed in pre-formed LLD/BA/Nylon-6/BA/LDPE pouches and stored at 30°C. The shelf life of control sample was 40 days, the product with BHA alone had a shelf life of 50 days and the product containing BHA and potassium sorbate had a shelf life of 60 days [74].

### **Kalakand**

Kalakand is another unique khoa-based sweetmeat. It is popular all over the Indian sub-continent. It is partially desiccated milk based sweet prepared from acidified milk with caramelized flavour and granular texture. Rao and Goyal [75] prepared kalakand using the method of De [5] with a slight modification i.e. by using 0.025% citric acid instead of 0.5%. Buffalo milk standardised to 6% fat and 9% SNF was used. The citric acid solution was added at a later stage when the concentrated mass started losing the side of the vessel. Jadhav et al. [76] replaced the milk from 5 to 15% by the bottle gourd pulp. The control sample of kalakand had significantly higher sensory scores for all the parameters as compared to the sample with 10 and 15% bottle gourd pulp. However, control and

kalakand with 5% bottle gourd pulp did not differ significantly from each other and both were comparable sensorily. So far, no compositional standards for kalakand have been laid down under either in the erstwhile Prevention of Food Adulteration (PFA) Act, the current Food Safety and Standards Rules (FSSR) [18] or by the Bureau of Indian Standards (BIS).

Rao and Goyal [75] evaluated quality of kalakand stored in five different types of packages i.e. vegetable parchment paper, metallized polyester (with and without vacuum) and LDPE (with and without vacuum) at 30±1°C, RH 65% and 6±1°C, RH 90% for various time intervals. It was reported that sensory scores of kalakand were affected by the type of package and also by the duration of storage. Sucrose was replaced with artificial sweeteners like saccharin and acesulfame-K in the preparation of kalakand. Saccharin at the level 0.015% and acesulfame-K at the level of 0.045% resembled control kalakand in sweetness. Saccharin and acesulfame-K were recovered to the extent of 92-97% and 90-96%, respectively. HPLC analysis also revealed no degradation of saccharin and acesulfame-k in kalakand establishing their stability and hence retention of sweetness on storage [77].

### **Rabri**

Rabri is a concentrated, sweetened whole milk product, containing several layers of clotted cream. While the milk is slowly evaporated, without being stirred, at simmering temperature in a traditional open shallow pan over an open fire, pieces of skin which form on the surface of the milk are continuously broken up and moved to the cooler parts of the pan. Sugar is added when the volume of milk has been considerably reduced, layers of clotted cream are immersed in the mixture and the finished product is obtained by heating the whole mass for a short period. It contains all the milk solids in an approximately five-fold concentration, with additional sugar. Consumed directly, it has a high food and nutritive value, with approximately 20% fat, 10% protein, 17% lactose, 3% ash, 20% sugar and 30% moisture [9]. The concentration of different components in rabri varied widely due to the initial composition of milk, degree of concentration of milk solids and amount of sugar added [5]. A method was standardized for rabri manufacture by Gayen and Pal [78]. One kg buffalo milk (6% fat) simmered in a steam jacketed kettle at 90°C, after three-fold concentrations gave a yield of 100 g clotted cream. Pal et al. [79] successfully used TSSHE for the large scale production of rabri. It involved standardization of buffalo milk to 6% fat, addition of sugar @6% to preheated (85-90°C) milk and concentrating in TSSHE upto 50% solids, addition of shredded paneer and packaging in hot conditions (80°C) and immediately cooling. Chopde et al. [80] optimized the process for in-line production of rabri. They integrated the Scraped Surface Heat Exchanger (SSHE) with Conical Process Vat (CPV) and optimized the process parameters using response surface methodology. The research revealed that rabri of better sensorial,

chromatic and textural attributes can be manufactured.

### **Khurchan**

Khurchan, is a major delicacy, which originated in the town of Hathras, Uttar Pradesh, India [7]. It is a heat desiccated, sweetened whole milk product traditionally prepared in a shallow open pan by simmering the milk without stirring so as to allow for instantaneous formation of a thick creamy layer of skin on the surface of the milk after slow evaporation of water. Sugar is added to the concentrate followed by a thorough mixing of the product. Average composition of khurchan is 27.9% moisture, 23.6% fat, 15.4% protein, 14.9% lactose, 15.2% sugar and 3.0% ash [10]. It contains all the milk solids in an approximately five-fold concentration, together with the addition of sugar, which makes its food and nutritive value very high.

### **Kunda**

Kunda, is an Indian traditional heat desiccated dairy product, popular in the state of Karnataka in India, especially Belgaum and its neighbouring areas. Manufacture of kunda is a time consuming and energy intensive process and the process involves consumption of large quantities of steam for evaporation of water [81]. It is prepared by continuously heating a mixture of khoa and sugar with intermittent addition of water until the characteristic brown colour is obtained. It is characterized by a semi-brown to brown colour, soft body and grainy texture, and characteristic sweet, nutty and pleasant flavour. Kulkarni et al. [82] standardized the methods for manufacture of kunda. The khoa generally used for kunda making has high moisture content (40%). If the khoa used is low in moisture content, then about 10% of milk is added. After the addition of calculated amount of sugar (25-30%), khoa is subjected to slow desiccation on direct fire. At the end, a brown mass with granular texture is obtained which has about 25% moisture.

### **Basundi**

The exact origin of Basundi is not known but it is reported to have been prepared over several centuries in the western and southern parts of India. It is served during special festivities such as weddings and religious functions. It is analogous to rabri and khurchan which are popular in the northern and central parts of India [7]. Basundi is comparatively less thickened and normally does not contain flaky/layered texture as in the case of rabri. It is similar to sweetened condensed milk with the exception that it has a pleasant heated flavour and slightly brown colour [83]. Traditionally, basundi is made from buffalo milk by progressive boiling resulting in more and more skin formation, skin is removed and collected on topside of the karahi and when desired concentration is reached the sugar is added in the ratio of 10:1. Milk is concentrated about two-fold and stirred heat coagulated film of milk gives desired typical soft textured flakes which remain uniformly suspended in thickened milk. Cardamom and/or

saffron are also added. Basundi is served chilled, often garnished with slices of almonds and pistachios. Different types of basundi are also prepared like Sitaphal (custard apple) basundi, Angoor basundi (basundi with small rasogolla balls), etc.

A process for commercial manufacture of basundi has also been developed. As per this process, buffalo milk having good heat stability (negative alcohol test), standardized to 0.05 Fat/SNF ratio is taken in an open steam jacketed kettle and is preheated to 90°C for 10 min. Partial concentration upto 2-fold is done in a batch-type steam jacketed stainless steel open, wide-mouth pan. Crystalline cane sugar is added at this stage @5.5% (w/w) of milk and concentration is continued up to 2.5 fold of original total solids including sugar [11,12,84,85]. Basundi is then transferred hot in containers, cooled to 10°C and is stored under refrigeration (7±2°C). Homogenization after concentration of milk could be advantageous for improving the viscosity of the product [86]. Autoclaving for 10 min i.e. post-production heat treatment is given to enhance the shelf life of basundi and this is reported to increase the shelf life up to 40 days when stored at 7±2°C [87]. Different methods of milk concentration viz. open pan, under vacuum and a combination of Reverse Osmosis (RO) and open pan concentration have been used for basundi manufacture. Except for the significant decrease in lactose content in RO concentrated product and significantly higher ash content observed in vacuum concentrated product, no other major compositional changes were observed because of the method of concentration [88]. Mechanization of the basundi production has also been reported by Patel et al. [89] who developed Continuous Basundi Making Machine (CBM) based on the principle of TSSHE. The standard process and CBM is energy efficient and the quality of the product is better compared to traditional product as concentration of milk takes place at atmospheric pressure and sugar dosing develops typical pleasant caramel flavour. Rajshekhar et al. [90] studied the effect of shape of SSHE on heat transfer coefficient in basundi making. They used cylindrical, conical and karahi shape SSHE. It was reported that in case of karahi type SSHE, the heat transfer area per unit amount of milk in the SSHE is higher as compared to the other two types of the models, which resulted in increase in heat transfer rate and the rate of evaporation of water from the milk.

### **Gundpak**

Gundpak is a khoa-based dairy product made by cooking the blend of khoa, sugar, ghee and fried gund in ghee with proper agitation and mixing of ground dried dates (chokada), nuts (cashew nut, almond, coconut, pistachio) and spices (cinnamon, clove, small cardamom, large cardamom) followed by topping with partly fried watermelon seeds and dry grapes. Herbal plants powder may be added as an optional ingredient for the development of characteristic flavor and therapeutic value of Gundpak. Gundpak is a protein-energy rich delicious and nutritious sweet

milk product. The demand of the product is increasing throughout the country as well as outside day by day. The total production of gundpak in Kathmandu valley in the fiscal year 2010 was approx. 579.1 MT, worth of NRs. 192.5 million [91,92]. Gundpak being a traditional product of Nepal, neither specific recipe nor mechanized processing conditions for its large-scale production is standardized or validated. Gundpak sold in the local market vary widely in appearance, texture, composition and nutritional quality. Acharya [93] optimized the ingredients levels for the production of gundpak using response surface methodology. He reported that the optimum level of ingredients viz. khoa, ghee, sugar and gum for the best product were 74.2 (67.64%), 5.0 (4.56%), 30.0 (27.35%) and 0.5 (0.45%) grams respectively.

### **Bomboyson**

Bomboyson is a traditional dairy product of eastern hilly region of Nepal. It is prepared by cooking khoa with ghee and sugar. It is a sweet, dark brown coloured product with caramelized flavour. It has potential for commercialization but no standardized method is available for its large-scale production. Gartaula and Bhattarai [94] carried a study to standardize this product for the organized production. Furthermore, they had also made an attempt to replace sugar by jaggery in order to improve its nutritional quality. They reported that bomboyson prepared from 100 parts khoa, 40 parts sugar and 20 parts ghee gave the best result in terms of sensory analysis. Replacing sugar by jaggery in the product increased the mineral content and was sensorially accepted. The product has a shelf life of 28 and 21 days at 5°C and 25°C respectively.

### **Payasam**

Payasam is a traditional sweet delicacy of South India. The basic method for preparation involves cooking pulses, cereals or cereal products, sago, poppy seeds or fruit pulps (mango, banana or jackfruit) in milk or coconut milk. Dried fruits and nuts are added to some varieties as are cardamom, camphor or saffron. Prajeesha and Rao [95] developed a technology for bamboo seeds payasam. The bamboo seeds payasam is a light brown to dark brown coloured product, the dark colour is due to dark jaggery used in its preparation. Various ingredients of bamboo seeds payasam, viz. amount of bamboo seeds, water, jaggery, fresh coconut extract and milk along with process for preparation were optimized. Preparation starts from cleaning, washing and soaking of bamboo seeds followed by pressure cooking. The cooked grains then mixed with jaggery syrup, coconut extract and toned milk. The entire mixture was then heated and desiccated to a flowable consistency till pleasant caramelized taste is obtained. Payasam has a shelf life of 1-2 days and more than 15 days at 30°C and 5°C respectively.

## **Developments in Packaging**

Packaging has a significant role in the food supply chain and is an integral part of both the food processes as well as the

whole food supply chain [96]. Food packaging performs a number of tasks: it protects the food from contamination and spoilage; it allows easier transportation and storage of foods; and it makes advertising meaningful and large-scale distribution and mass merchandising possible.

In recent years, heat desiccated traditional milk-based sweets have been gaining significant importance in Indian dairy industry and also the popularity for the products like khoa, burfi and sandesh have increased in western countries and a lot of export potential exists for these products. However, due to increased demands from consumers in terms of product safety, shelf-life extension, cost efficiency, environmental issues and convenience, food packaging no longer has just a passive role in protecting and marketing the product. In order to improve the performance of food packaging in meeting varied demands of stake holders in the entire supply chain, many new functions have been introduced in packaging technologies to make it active. In this direction, new and innovative packaging technologies such as modified and controlled atmosphere packaging, active and intelligent packaging, antimicrobial packaging and nano-packaging technologies are being developed, tested and optimized around the world [97-99].

### **Modified Atmosphere Packaging**

The intrinsic properties of individual dairy and food products are responsible for quality changes and also it is evident that their shelf life is limited in the presence of normal air. There are two principal factors that are responsible for the deterioration of dairy products: first being the chemical effect of atmospheric oxygen and second the growth of aerobic spoilage microorganisms. These factors are responsible for changes in odour, flavour, colour and texture leading to an overall deterioration in quality either individual or in association with one another. The modification of the atmosphere within the package by reducing the oxygen content while increasing the levels of CO<sub>2</sub> and/or N<sub>2</sub> has been shown to significantly increase the shelf life of perishable foods at chill temperatures. The principle of Modified Atmosphere Packaging (MAP) involves the removal of air from the pack and its replacement with a single gas or a mixture of gases by either passive or active methods. The three major gases used in the MAP of foods are O<sub>2</sub>, N<sub>2</sub> and CO<sub>2</sub> [100].

### **Active and Intelligent Packaging**

Besides providing a protective atmosphere, packaging material itself may play an active role in enhancing the shelf life of product by nullifying the rate of deteriorative reactions, by arresting the growth of spoilage/pathogenic microorganisms. This has led to the concept of active packaging. Active packaging technologies involve interactions between the food, the packaging material and the internal gaseous atmosphere and play a dynamic role in food preservation. Active packaging senses environmental

changes and respond by changing its properties. In other terms, active packaging is a group of technologies in which the package is actively involved with the food products or interacts with the internal atmosphere to extend the shelf life, while maintaining quality and safety. It is achieved by the use of absorbers, emitters, scavengers, scrubbers and desiccants that when added to a package, alter the package structure, function or properties [101]. Diverse functions that the active substances perform include oxygen scavenging, anti-microbial activity, moisture control, ethylene removal, antioxidative reactions etc. Intelligent packaging is designed to monitor and communicate information regarding the present properties of the food, or records aspects of its history about food quality to the consumer [102]. It involves devices attached as labels, incorporated into or printed onto a food packaging material that offer enhanced possibilities to monitor product quality, trace the critical points and give more detailed information about the supply chain.

Although this technique has not yet received importance in India, due to the non-availability of active agents locally, but, recently, Chaturvedi [103] has applied oxygen scavengers to extend the shelf life of khoa-jalebi, another region-specific heat desiccated traditional dairy product and reported that the shelf life of the product increased from 10 days to 42 days when stored at 30°C and 65% RH.

### **Antimicrobial Packaging Systems**

Antimicrobial packaging system is a type of active packaging, that can take several forms such as: addition of sachets/pads containing volatile antimicrobial agents into packages, incorporation of volatile and non-volatile antimicrobial agents directly into polymers, coating or adsorbing antimicrobials onto polymer surfaces, immobilization of antimicrobials to polymers by ion or covalent linkages and use of polymers that are inherently antimicrobial [98].

### **Edible Films and Coatings**

Edible packaging consists of edible films, sheets, coating and pouches. Edible films and sheets are stand-alone structures that are preformed separately from the food and then placed on or between food components or sealed into edible pouches. Edible coatings, on the other hand, are thin layers of edible materials formed directly onto the surface of food [104]. The edible films comprise of thickness of less than 254  $\mu\text{m}$ , whereas edible sheets include up to thickness of 254  $\mu\text{m}$  [99]. The edible packaging materials offer multifunction, like offer a selective barrier to retard the migration of moisture, gas transport, oil and fat migration and solute transport; improve the mechanical handling properties of foods; improve the mechanical integrity or handling characteristics of the food; retain volatile flavour compounds and carry food additives such as antioxidants and antimicrobials [105].

Although edible coatings look simple, its application for traditional dairy products is rather tricky as one has to maintain the unique sensory attributes of these products. In this direction some successful attempts were made to enhance the shelf life of traditional dairy products such as paneer by developing edible antimicrobial films [106].

### **Biodegradable Packaging**

Food packaging is the largest user of plastics (~40%), which, in spite of their versatility, are poor barrier to gases and vapors, including oxygen, carbon dioxide and organic vapors. Further, they are considered a menace to environment once they reach municipal solid waste (MSW) and/or landfills, as they are not biodegradable [107]. Consequently, the approach of making packaging materials from biodegradable materials that can be disposed of through composting or recycling got momentum. As a result, a number of biodegradable materials such as naturally occurring polymeric materials, polymers made by polymerization of organic molecules and biodegradable polymers from petrochemicals have been investigated for use as alternative to plastics. Biopolymers from agricultural food stocks, food processing waste and others have the ability upon blending and/or processing to result in biopolymeric packaging material called as biodegradable polymers or bioplastics [108]. Recently, Kumar [109] developed a nano-composite biodegradable packaging film using sodium caseinate and corn starch, which was found to be completely biodegradable within 120 hr under the soil burial conditions. Such film was attempted for packaging of burfi, another khoa-based confection.

### **Nanocomposite Packaging Materials**

Polymer nanocomposites are created by dispersing an inert, nanoscale filler throughout a polymeric matrix in which the filler has at least one dimension smaller than 100 nm. Filler materials could be either flakes, fibers, whiskers or nanoparticles. The mechanical, thermal and barrier of nano-composites are often remarkably different from those of non-reinforced synthetic or biopolymer-based materials. Addition of relatively low levels of nanoparticles (less than 5%) have been shown to substantially improve the properties of finished plastic, increasing the deformability and strength, and reducing the electrical conductivity and gas permeability. Widely used filler materials are clay and silicate nanoplatelets, silica ( $\text{SiO}_2$ ) nanoparticles, carbon nanotubes, grapheme, starch nanocrystals, cellulose-based nanofibers or nanowhiskers, chitin or chitosan nanoparticles, silver nanoparticles ( $\text{AgNO}_3$ ), titanium nanoparticles ( $\text{TiO}_2$ ), magnesium nanoparticles ( $\text{MgO}$ ), copper nanoparticles ( $\text{CuO}$ ), zinc ( $\text{ZnO}$ ) etc. [110]. Recently, Kumar [109] developed a nanocomposite biodegradable packaging film using sodium caseinate, corn starch and nanoclay (organically modified montmorillonite) which was cross linked with formaldehyde. The studies revealed improved mechanical strength in the film. Such film was applied as a sealant

layer for polystyrene trays for packaging of burfi.

### **Retort Processing**

Retort processed foods offer long-life and convenience for which packaging materials play an important role. Kunda, a heat desiccated dairy product was packaged in pouches and retort processed in order to enhance the shelf-life. The packaged and retort processed kunda was stored at 37 and 55°C and the changes in rheological, microbial and sensory quality were monitored at regular intervals by Navajeevan and Rao [111] was reported that during storage, the processed kunda showed a gradual increase in its rheological (firmness, consistency and adhesiveness) properties indicating that retort processed kunda became firmer and more adhesive during storage. It was concluded that the spoilage of retort processed kunda was more of physical in nature than a microbial one.

### **Market Potential**

The milk produced in India is distinctly seasonal. It comes from cows and buffaloes in equal proportion, with a small contribution from goats. The growth in milk production reflects India's unique history, industry and policy structure set up under Operation Flood which the Indian Government, the World Bank and the European Community food aid funded. It was designed to achieve milk self-sufficiency early next century. Annual production of raw milk from all sources in India is 146.3 million tons having increased from 20 million tons in 1970, and is expected to reach 150 million tons by the end of the year 2016 [112].

Operation Flood is a system of rural milk producer co-operatives that purchase, process and market milk, provide technical services and infrastructure. The early funding of Operation Flood One was done through commercial resale of dairy product received as aid under the World Food Program. The product came from the European Community and the revenue from sales of aid product was used to develop infrastructure for local co-operatives. Operation Flood Two set up the institutional framework comprising a three-tiered co-operative structure of

societies, unions and federations. Operation Flood is now in its third stage and involves eight million dairy farming families. There are 200 milk processing plants in the co-operative, government and private sectors which receive 11 million litres of milk per day and the Operation Flood dairies market three-quarters of this total. Under the Operation Flood scheme, daily supplies of milk are collected from over 60,000 village milk procurement centres to meet consumer demand for drinking milk. This accounts for 5.5 million tons or ten per cent of total milk produced. The remaining 90 per cent of milk is utilised on-farm, sold to small operators in nearby towns, or used to produce ghee or other products.

In India, even after nearly three decades of organised milk procurement and market intervention under the Operation Flood programme, of the estimated 30 per cent of the total production which is marketed by the village producers (after meeting the local consumption needs, of both the producers and the non-producers), only 35 per cent is collected by the organised processing sector and the rest by the traders of all hues. Households and unorganised sector (halwais and milk vendors) handle about 82% of the total milk production and the rest by the organised sector. Of the total milk production, about 50% is being converted into indigenous dairy products. The market of Indian milk products is estimated to be more than Rs. 65,000 crores. A few organised sectors started production of Traditional Milk Products (TDPs) on a commercial scale, but this impact is still limited. According to another estimate, 28 per cent of total production is converted into ghee and another 20 per cent into milk products, such as dahi (curd), khoa (dehydrated milk) and a variety of milk-sweets, to enhance shelf-life [3]. The villagers try to conserve milk in its freshness, before it becomes sour which makes possible better recovery of milk solids in the products that are made. Much Indian milk production is seasonal in character as nearly half the production is by buffalo which are seasonal calvers. Seasonal surpluses are converted into the above products for which there is a premium in India. The pattern is much the same in Pakistan, Bangladesh, Nepal and Sri Lanka. The generalised flow of milk from the producer to the consumers is depicted in Figure 4.

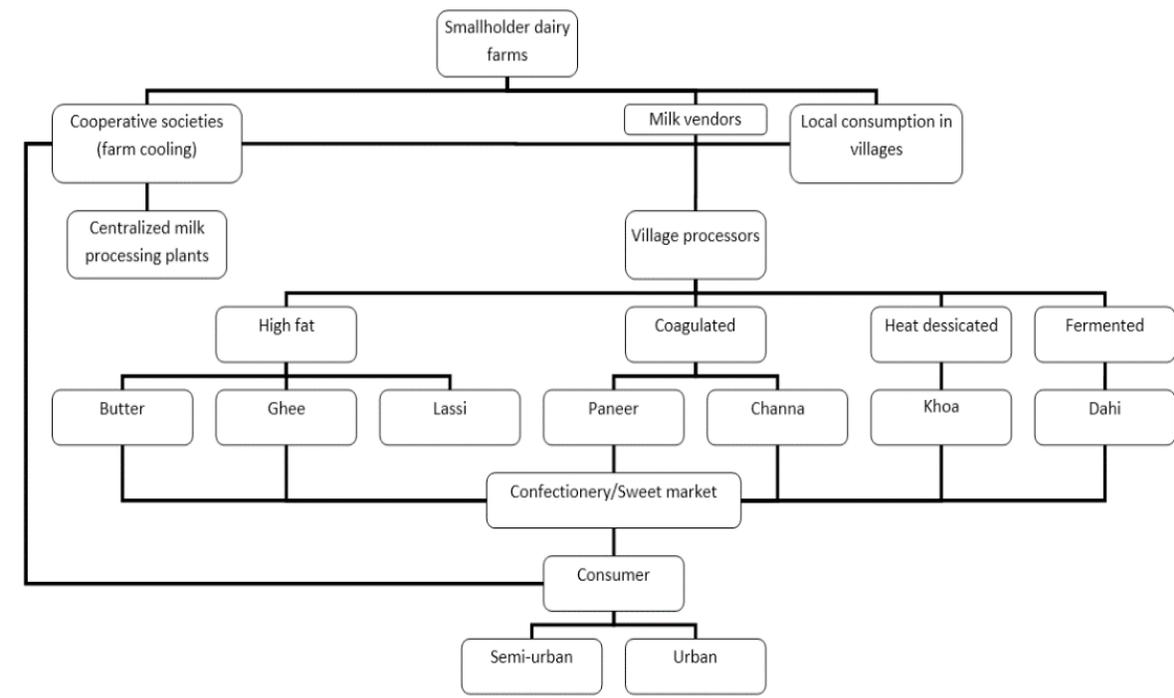


Figure 4: Milk movement scenario in the Indian sub-continent.

The demands of consumers in the four major cities of India: Bombay, New Delhi, Calcutta and Madras, and the regional variations in milk supply, led to the establishment of a National Milk Supply Grid system via train and road tankers. Rural producers are linked with urban consumers through the National Milk Supply Grid by moving milk from surplus to deficit regions. Barriers to trade are substantial and there is a domestic dairy policy of increased self-sufficiency. India's imports have been declining as a proportion of total production. Imports are subject to 60 per cent tariffs, plus state sales taxes and general excise duties [113,114].

The TDP market is the largest in value after liquid milk and is estimated at US\$3 billion in India and US\$1 billion overseas. Some 900,000 tonnes of khoa valued at Rs 45,000 million is produced in the country. Approximately 1,20,000 tonnes of chhana (coagulated milk product), valued at Rs 6,000 million is produced. Almost all the milk sweets in India are made from two base materials - khoa and chhana. The traditional dairy products sector in India is grossly undermanaged, but provides economic opportunities. A niche global market has strongly emerged for ethnic Indian dairy products. Our NRIs are estimated to be 30 million, so opportunity to take the advantage of this niche market exists.

## Conclusion

Heat desiccated traditional milk products are known from the ancient times and are an integral part of dietary habits and cultural

heritage in Indian sub-continent. They have great social, religious, cultural and economic importance. In addition to preservation of milk solids for a longer time at room temperature, manufacture of heat desiccated dairy products, add value to milk and also provide tremendous employment opportunities. In this category, khoa is of great commercial importance due to its use for the preparation of variety of indigenous sweets. For mechanization of technology for khoa, significant research has been done and it can be concluded that TSSHE and ISSHE equipment have great potential for industrial use. Most of the heat desiccated dairy products are well characterized and methods of manufacture have been standardized using mechanized or semi-mechanized systems. In view of India's pre-eminent position in milk production and the need to bring more and more milk processing in organised sector, more focussed research and development in the area of mechanized manufacture of indigenous milk products is the need of the time. Growing population of diaspora from Indian sub-continent in Europe, USA and Canada, a huge market growth of these products is envisaged in next few years. Issues such as quality, safety, packaging, shelf life, nutrition and health associated with these products will need to be looked into with renewed research and development focus.

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