Chapter 11

PACKAGING ASPECTS OF MILK & MILK BASED PRODUCTS

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INTRODUCTION

Traditional milk-based products have played a significant role in the cultural and nutritional areas of our country. More often, these products are produced in unorganized small-scale sector. Although standardization in quality and mechanization in production are taking place, there is a great need for the development of appropriate and economical packages.

Packaging is the vital link in the entire chain of production, storage, transportation, distribution and marketing. Functional packaging of dairy products leads not only to resource raising and their optimal utilization, but also protects the contents against deteriorative changes and associated hazards.

LIQUID MILK

Liquid milk forms a major item of food in our country especially in rural areas. It forms the major ingredient in beverages, tea and coffee and essential part of the diet either as milk itself or as curd, butter milk, ghee and savories.

Surplus milk is marketed by door-to-door vending and the containers used are often unhygienic. Also, loose-vending introduces the possibility of mixing with water and also harmful ingredients. Hence, proper packaging assumes greater importance in the distribution of raw and pasteurized milk in hygienic and wholesome form in specified volumes leading to consumer convenience and safety.

Milk, being a complex physico-chemical system, consists of a water solution of salts, lactose, lactalbumin, etc. Proteins are dispersed in a colloidal form while milk-fat solids are present in a partially emulsified suspension.

Milk is susceptible to oxidation of fat (phospholipids in milk) which produces a waxy odour. This dete-riorative change is enhanced by heat, acid and metallic ions. Exposure of milk to natural and artificial (fluorescent) light leads to deterioration in quality and loss of vitamins.

Hence, a package intended for milk should possess the following protective functions:

i) Protection against contamination due to dirt and microorganisms.

ii) Protection against light and heat.

iii) Protection against external odours.

iv) Physical protection to withstand distribution hazards.

Bulk Distribution of Milk

The conventional containers for bulk packaging and distribution are the aluminium cans with lids, while in recent years, bulk vending by machines through operation by token system has become popular. This system is now operating successfully in many cities. Bulk vending is well suited to Indian consumers since it allows the purchase of relatively small quantities of milk, two times a day and use of buyers' own containers avoiding the cost and inconvenience of handling bottles or pouches. The system ensures hygienic, good quality milk at a price reflecting low overheads and low packaging costs.

It is claimed that the capital cost of bulk vending system is nearly 20% less than the bottling system and the operating and running cost less than 50%. The milk losses are claimed to be between 0.50 and 0.65%.

Distribution in Bottles

This was the most universally accepted milk distribution system before the advent of single-serve containers. The bottling system is highly capital intensive — not only the bottle filling and washing machines are costly, but the system requires larger operational areas, large store space, and fully automatic machines are difficult and expensive to maintain while the manual systems require a large labour force.

Transport costs for distribution are high since the weight of empty bottles and crates is nearly the same as that of the quantity of milk distributed. The collection, washing and accounting of return bottles is costly and cumbersome.

In the context of existing bad roads in most of the cities and unsystematic handling operations, the bottle breakage is very high. This leads not only to higher milk losses, but also to added cost of handling. The milk losses vary between 1.0 and 1.5%.

Distribution in Non-Returnable Containers

Plastic pouches: Most of the dairies in cities of India have introduced packaging and distribution of milk through polyethylene pouches. The plastic pouches are single-trip packages, very light in weight, and hence distribution costs are less compared to glass bottles. Losses during pouch filling are less than bottle filling and less floor space is required for packing section and cold storage.

Bureau of Indian Standards prescribes requirements and testing of polyethylene pouches for the packing of pasteurized liquid milk in 1 litre and ½ litre capacities in IS:11805-1986. According to this standard, the pouches should be made from virgin polyethylene (LDPE, LLDPE, HDPE or EVA) for meeting the food grade requirements.

Initially, LDPE film was used for milk packaging but now LLDPE is the preferred choice. More recently, octene and butene-based LLDPE are used due to the following factors:

i) Reduction in losses due to leakage. Average losses due to leakage vary from

1-5% with LDPE film and 0.6% with LLDPE film.

ii) Reduction in the area of pouches to suitable limits by reducing the length of pouches. This leads to saving of 3 pouches/kg and 1 pouch/kg for 0.5 and 1.0 litre pouches respectively.

iii) Enhancement in yield (number of pouches per kg) by down-gauging. It has been shown that by reducing the thickness of film by one micron only, 1 kg of film will give 9 half-litre pouches and 6 one-litre pouches more.

It has been shown that coloured cartons (Purepack) and pigmented pouch (black) with light transmission of less than 1% in the visible spectrum were very effective in preventing light induced changes in milk (350-750 nm) whereas polyethylene jugs with 2% titanium dioxide were not very effective.

The revised BIS Standard (2003) for polyethylene pouches for packaging liquid milk - specifications (2nd revision) indicates that the material shall be made from virgin polyethylene (LDPE, LLDPE or a blend thereof) trim meeting the food grade requirements. Coextruded 50:50 blend of LDPE of melt flow index (MFI) 0.5 and octene - LLDPE of MFI of 1.0 is the common film in vogue.

The specification IS 11805 specifies the thickness (85 µm for 1 litre and 75 µm for 0.5 litre pouch), yield strength (11.77 MPa and 8.33 MPa for the machine and transverse directions), elongation, dart impact strength and slip. It also specifies tests on leakage (drop) and ink adhesion.

Paperboard Cartons

The material cost for paper board cartons is very high so also the capital cost of filling machines. The overall distribution cost for pasteurized milk in carton is said to be more than 1½ times as compared to the bottles and for sterilized milk aseptically packed, it is more than twice. Since this precludes the capture of major share of market, however, it can be used to meet the requirement of specific market segment.

Liquid milk is packed in carton systems of Tetrapak, Tetrabrik and Purepak (Fig. 11.1). The equipment necessary to produce tetrabrik is expensive to instal, but its advantages include a PE-lining which is strong and does not leak, and a lower price per unit of milk in running costs.

The comparative distribution costs for milk in bottles, pouches and bulk vending systems are given in Table 11.1.

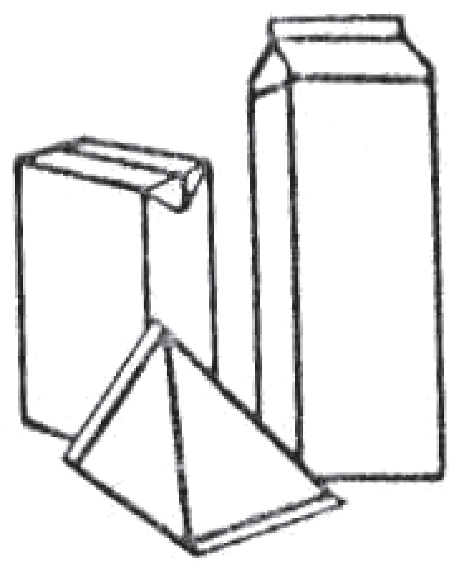

Fig. 11.1. Tetrapak, Tetrabrik and Purepak cartons

Table 11.1. Comparative distribution costs for milk

Factor		Distribution cost *(paise per litre)*		
		Bottles	Pouches	Bulk vending
1.	Annual running cost (Energy + Spares + Storage + Labour + Admn. expenses)	11.9	7.6	5.4
2.	Packaging material + Crates	10.5	25.5	-
3.	Milk losses	5.0	7.0	2.5
4.	Transport & Distribution	11.2	7.5	6.5
5.	Retailer commission	10.0	10.0	10.0
6.	Interest + depreciation on packing & distribution equipment	5.4	3.0	4.5
	Total cost	**54.0**	**60.6**	**21.9**

Sterilized Milk

The ultra-high temperature treatment of milk sterilization kills all vegetative cells and spores with very little effect on flavour or loss of nutrients.

The milk is then filled in sterile containers (for ex., Tetrabrik cartons) under aseptic conditions. Such cartons made of paper board/aluminium foil/PE, in the absence of ambient air provided best protection against loss of ascorbic acid and vitamin B (riboflavin and folic acid) and maintained best organoleptic properties when stored upto 4 months at ambient temperature conditions. In the presence of air, the keeping quality was maintained upto 3 months. Sterilized milk when packed in ordinary plastic containers acquired unacceptable smell and taste.

TRADITIONAL MILK-BASED SWEETS

In general, the requirement of a package for traditional milk-based sweets are:

- Protection against ingress of water vapour resulting in loss of texture, hydrolytic rancidity, microbial growth, etc.
- Protection from deleterious reactions due to oxygen, both chemical, nutritional and microbiological.
- Avoidance of tainting from external sources leading to development of off-odours.
- Good resistance towards exudation of oils and fats — grease-resistance.
- Freedom from metallic and chemical contaminations.
- Conformity to national and international specifications and standards.

In the case of milk-based sweets, as in the case of all food products, the relationship between the moisture content and the water activity is the prime factor indicating chemical, physical and microbial interactions.

It is not moisture content *per se*, but the water activity which determines the spoilage of foodstuffs. Spoilage in milk-based foods is mainly due to proteolysis, lipolysis, oxidative reactions, texture and flavour changes and onset of microbial growth. Considerable amount of research work has been carried out on these aspects in relation to water activity. The possibility of preservation effect of reduced water activity in combination with other preservatives is gaining importance.

From the packaging point of view, indigenous milk-based confections can be divided into three categories, those with low water activity, intermediate water activity and high water activity and the packaging aspects will be considered on these lines.

Foods with Low Water Activity

These are foods having low moisture content and equilibrating to 0.3 to 0.4 water activity at normal temperature. These comprise ready mixes such as *gulab jamun*, *kheer*, ice-cream mix, malted milk foods and mita chocolates.

Ready *gulab jamun* mix consists of wheat flour, skimmed milk powder, edible oil, ghee and leavening agents. IS:12220 (1987) specifies a maximum moisture content of 8%, minimum fat of 12%, maximum carbohydrate of 60% and absence of coliform and *Staphylococcus*. Packaging and marking specifications are that the ready *gulab jamun* mix shall be packed in flexible food grade hermetically sealed pouches or in other sound moisture-proof containers.

Gulab jamun mix consisting of roller-dried skim milk powder (4.5%), bleached wheat-flour (*maida*) 25%, semolina 15%, butter fat 15%, baking powder 1.5% and ground cardamom 0.1% and packed in 75 μm LDPE film pouch had a shelf-life of more than 120 days at 30°C and 70% RH condition. The changes in *gulab jamun* mix stored in four types of flexible packages are presented in Table 11.2.

Foods with Intermediate Water Activity

Khoa or *Mawa*

This is essentially prepared by partial dehydration of milk under controlled conditions. It forms an important base for the preparation of indigenous milk sweets such as *burfi, peda* and *jamun*.

Studies were carried out on packaging of *khoa* (500 g) in 5 types of pouches and were stored at (a) 37°C, (b) 8°C and (c) -20°C and analyzed for moisture, acidity, peroxide value, free fatty acid and also sensory and microbiological qualities.:

i) Vegetable parchment paper

ii) MS DT cellophane/LDPE

iii) High-density polyethylene

iv) Paper/PE/Al.foil/PE

v) Paper/PE/0.02 mm. Al-foil/PE

Khoa samples packed in parchment and HDPE were found satisfactory up to 5 days at 37°C and good up to 14 days at 8°C. At -20°C condition, storage studies up to 75 days indicated that *gulab jamun* made from *khoa* were of good quality in all the packaging materials.

Hot filling (80-90°C) of *khoa* in tinplate containers provided shelf-life up to 14 days at 37°C, while the use of laminates paper/foil/PE or poly cell provided 10 days storage life at 37°C and 60 days refrigerated

Table 11.2. Changes in organoleptic qualities of packed *gulab jamun* mix at 30°C

Package Type	Storage period	Penetration value	Texture	Flavour	Overall acceptability
Initial	-	148	25.6	32.3	91.6
LDPE / LLDPE	60	158	26.0	31.2	90.5
	120	178	26.3	29.9	89.3
	180	207	26.8	29.1	88.3
	240	246	27.3	28.1	87.6
MXXT Cellophane	60	160	26.2	31.5	91.2
	120	181	26.9	30.6	90.4
	180	207	26.9	30.4	90.1
	240	253	27.4	30.1	90.0
Paper / Foil / PE	60	175	26.4	31.7	91.1
	120	190	26.9	31.21	90.7
	180	220	27.0	30.8	89.9
	240	272	27.5	29.6	89.1
MetPET / PE	60	175	26.4	31.6	91.2
	120	186	27.0	31.5	91.4
	180	218	27.0	29.8	88.5
	240	269	27.3	28.3	86.9

condition. Four-ply structure of CPP/ LDPE/Al-foil/PE increased the shelf-life to 14 days at 30°C and 75 days in the cold storage. The chemical quality changes in packed *khoa* and stored at 4-5°C are shown in Table1. 11.3.

Flexible packages can be exposed to gamma-radiation for sterilization, prior to filling. Addition of 0.3% potassium sorbate at the last stage of *khoa* making also improves shelf-life by additional 10 days, provided aseptic precautions are taken during packaging.

Antioxidants such as BHA and TBHQ were found not effective as antimicrobial agents in improving the shelf-life of *khoa.*

Pedha

Pedha is the heat desiccated milk sweet prepared from *khoa* and sugar to provide the granular and hard texture and flavour. Since it is highly prone to the development

Table 11.3. Chemical quality changes in packed *khoa* (4-5°C)

Packaging material	Storage period (days)	Moisture content (%)	Titrable acidity, lactic acid (%)	FFA (%)	PV m.eqt/ kg fat
-	0	27.2	0.45	0.055	0.1
Paper (50 gsm)	20	27.1	0.49	0.074	0.1
Al.foil (0.02 mm)	40	27.0	0.54	0.089	0.1
LDPE (37 μm)	60	26.7	0.60	0.109	0.1
Paper (40 gsm)	20	27.0	0.51	0.080	0.1
Al.foil (0.015 mm)	40	26.9	0.57	0.099	0.1
LDPE (37 μm)	60	26.6	0.63	0.117	0.1
MST Cellophane	20	27.0	0.52	0.084	0.1
LDPE (37 μm)	40	26.8	0.58	0.105	0.1
	60	26.5	0.64	0.123	
Tinplate	20	27.1	0.55	0.090	0.1
	40	27.0	0.60	0.110	0.1
	60	26.9	0.67	0.130	0.1

of microorganisms, addition of preservatives like potassium sorbate, nisin, and sodium/ potassium bisulphite have been found useful in extending the shelf-life. Two different concentrations (0.02 and 0.05%) of sorbic acid when added to buffalo milk *pedha* was found to lower the enhance-ment of acidity, FFA, PV, proteolysis and inhibit microbial growth. *Pedha* containing 0.02% sorbic acid extended the shelf-life up to 9 days at 30°C and 37 days at 7°C. At a concentration of 0.05%, it was effective against chemical and microbiological deterioration up to 55 days at 7°C.

Pedha, with an initial moisture content of 14% (as is) or 16.3% (dry wt.) had water activity of 0.84 at 27°C. Storage studies on 100 g pedha packed in 12 x 15 cm pouches made of the following were undertaken:

i) 12 μm PET/9 μm foil/ 37um LDPE

ii) 12 μm PET/37 μm LDPE and

iii) 100 μm LLDPE/BA/PA/BA/EAA

The pouches under three treatments, (i) normal or with ambient air, (ii) vacuum and (iii) with free-oxygen absorber (FOA-Ageless SS 100) have been stored under accelerated and normal storage conditions. Samples were analyzed for head-space gas analysis, moisture, titratable acidity and changes in taste, aroma, texture and mould growth.

It was found that aluminium foil based laminate provided a shelf-life of nearly 30 days, while the composites based on PET or PA provided protection up to nearly 22 days, even under high temperature and RH (38ºC, 90% RH) conditions, when vacuum packed with respect to visible mould growth. However, vacuum packaging could not be recommended due to unacceptable changes. The corresponding shelf-life was more than 42 days under the storage conditions when packed with FOA. Inclusion of oxygen absorbent sachet extended the shelf-life considerably.

Burfi

Milk *burfi* is the most popular milk-based confection favoured for its taste and nutritional value. The several varieties of *burfi* are *mawa*, fruit, chocolates, coconut, *rawa* depending on the ingredients used, but all are based on *khoa* and sugar. IS:5550-specification (1970) for *burfi* has the requirement of 15% maximum moisture, 12.5% minimum milk fat, acidity max. of 0.35% and specification for sucrose, lactose and microbiological standards.

An optimum water activity of 0.70 is recommended for storage of *burfi*. At higher water activity, it becomes too soft and susceptible to mould growth, while at low water activities, the product loses moisture and the surface becomes dry and hard. Extensive studies have been carried out on storage studies of milk *burfi* in the following flexible packaging materials.

i) MSAT cellophane

ii) LDPE film

iii) HDPE film

iv) MSAT inside + HDPE outside

v) Glassine/PE laminate

vi) PVDC coated cellophane/PE laminate

vii) Polycell inside + PE outside

viii) Paper/Al.foil/PE

Burfi having an initial shelf-life of 6-8 days (due to mould infestation and surface drying), the addition of 0.15% sorbic acid and humectants like liquid glucose would extend the shelf-life to nearly 50 days when packed in folding cartons. Product containing sorbic acid and packed with polycell inner and PE outside did not show mould growth and surface hardening. This was acceptable even when stored for 90 days.

Burfi packed in vegetable parchment paper and stored at 36°C had good texture and flavour up to 15 days and that at 5ºC remained acceptable up to 50 days with some loss of moisture. *Burfi* packed in tinplate container and stored at 5ºC was acceptable for more than 150 days.

Chhana Butter-spread

Low-fat 60:40 butter and *chhana* spread with or without addition of 0.1% sodium benzoate and 0.1% potassium sorbate were stored in polystyrene containers at 4°C and 10°C. Storage at 4°C resulted in higher moisture loss and the shelf-life was 15 days at both temperatures for control sample. Sensory evaluation revealed that addition of potassium sorbate increased the shelf-life to 45 days at 10ºC and 60 days at 4°C and the use of sodium benzoate up to 60 days at 10°C and 75 days at 9°C storage temperature.

Foods with High Water Activity

Rasogolla and *gulab jamun* are the major milk sweets of high water activity while others are *paneer, channa, kulfi, sandesh* and curds.

Rasogolla

Rasogolla (including canning) is prepared in the following sequence:

Tinplate container of A 2½ size is the conventional package which provides best-before indication of 3 months from the date of packing. Alternatives to this are chrome steel (tin-free-steel) container with easy-open-ends. These are claimed to be economical and provide products with suitable organoleptic quality.

Another package which has good potential is the thermoprocessable (retortable) pouches made of laminates such as PA/CPP, PET/CPP and PET/foil/CPP. Also, solid PP containers with EVOH, where see-through possibility exists can be tried for processing and packaging of *rasogolla.*

Sandesh

The effect of various packages such as folding cartons, polystyrene and HDPE pouches, tinplate containers and nylon based pouches on the shelf life of soft grade buffalo milk *sandesh* stored at 30°C/70% RH and 7°C/90% RH have been studied. At both the storage conditions, maximum chemical, microbiological and organoleptic deterioration were found in the *sandesh* samples packed in paperboard carton, followed by PS containers, HDPE pouches and PA pouches.

At the high temperature/RH (38-40°C/ 90%) condition, the product in cartons and cans became unacceptable on 10th day with respect to flavour, but the extent of deterioration differed. At the low temperature condition, the product remained acceptable up to 30 days in cartons and 45 days in tinplate containers.

Fig.11.2. Packages for high water activity dairy products

OTHER MILK BASED PRODUCTS

Kunda is a desiccated milk product made by continuous heating of milk or high moisture *khoa* and specific amount of sugar which is very popular in the western region. The shelf-life studies on *kunda* has indicated light brown product kept well for about 4 days at ambient temperature compared to about 12 days in case of dark brown *kunda*. The spoilage was observed to begin with visible mould growth. Vacuumization and storing at low temperature (5-8°C) were found to provide shelf-life of 3-4 months.

Ghee

Traditionally, *ghee* is packed in tinplate containers which are suitable for long term storage. Retail distribution in 200 ml to 1000 ml in economical and functional flexible package is gaining acceptance, Storage studies in 200 ml units at accelerated and normal (BIS) conditions in the following materials have been carried out:

i) HDPE 85 μm

ii) Metallized PET/HDPE-LDPE (white opaque, 12.5 μm)

Fig. 11.3. Unit packages for Ghee

iii) LLDPE/T/PA/T/EAA, (White opaque), 95 μm

iv) HDPE/LLDPE (yellow), 100 μm

v) HDPE/T/PA/T/EAA (yellow), 120 μm

It was found that with equilibrium moisture content of 0.06 to 0.08%, the RH would be 20 to 32% with critical moisture content of 0.11% corresponding to 56% RH, at 27°C. Agmark and PFA specifications maxima are 0.3% and 0.5%, respectively.

Chemical and sensory analyses of the packed *ghee* has indicated that PE alone is not suitable for long storage. Co-extruded films based on polyamide and laminates based on PET can be preferred as good economical alternatives for longer shelf-life of more than 120 days at 27°C or normal distribution conditions.

Studies on the keeping quality of *ghee* in composite containers (body made of kraft/Al-foil/PE) with metal ends have shown that it provides shelf-life of more than 90 days even at higher temperature and RH conditions.

CONCLUSIONS

Bureau of Indian Standards (BIS) has formulated specifications for a number of indigenous milk-based sweets such as canned *rasogolla, khoa, chhana, paneer, burfi, chakka, shrikhand* and *dahi*. Clauses on packaging are also included in the specifications.

All plastic materials, lacquers and other components coming in direct contact with dairy products have to conform to specific regulations regarding actual transfer into them. Regarding adjuvants in packaging materials, only those materials listed and within the specified limits should be used. Global migration tests to be conducted depend on the type of product, i.e. aqueous, acidic and fatty/oily.

In conclusion, it can be said that milk-based products involve different types of packaging and it is very important that proper selection of materials and constructional features for packages is to be made so that the most appropriate new materials, methods and machinery are employed. The packages should be functional and economical and highlight the unique characteristics of particular food products.

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