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Review Article

Recent Development of Dried Fermented Milk Products: A Review

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A B S T R A C T

Fermented Milk products have great significance as they provide and preserve vast quantities of nutritious foods in a wide diversity of flavors, aromas and textures, which enrich the diet of human being. The primary function of fermentation is to extend its shelf-life, with added other advantage, like improving the taste of milk, biological value, enhancing the digestibility of the product and the manufacture of a wide range of products. The historical survey of the origin(s) of fermented milk products e.g. Ksihk, Cultured buttermilk, acidophilus sour milk, yoghurt, kefir, koumiss, Dahi, Srikhand etc exhibits that they date back to rely civilizations around 10000 BC. A wide range of indigenous fermented milk products are traditionally made in rural areas worldwide, and almost all of this products rely primary on spontaneous fermentation due to the presence of indigenous micro flora (mainly lactic acid bacteria) in the milk. The primary objective of drying of various Fermented milk products like Ksihk, Cultured buttermilk, acidophilus sour milk, yoghurt, kefir, koumiss, Dahi, Srikhand etc in powder form is to preserve it in a shelf-stable form of high quality without a need for refrigeration, improves the nutritive values, enhances better shelf life, easy to use and marketing of products . Such powder can be prepared by various methods, such as freeze-drying, spray-drying, microwave-drying and vacuum-drying. Dried fermented milk products are popular in various parts of the world and becomes an important in diets of various countries with consistent growth and demand worldwide.

Introduction

Fermented foods are of great significance since they provide and preserve vast quantities of nutritious foods in a wide diversity of flavors, aromas and textures, which enrich the human diet.

Fermented milks are prepared from milk and/or milk products (eg. any one or combinations of whole, partially or fully skimmed, concentrated or powdered milk, buttermilk powder, concentrated or powdered whey, milk protein (such as whey proteins, whey protein concentrates, soluble milk proteins, edible casein and caseinates), cream, butter or milk fat; all of which have been manufactured from raw materials that have been at least pasteurized) by the action of specific microorganisms, which results in a reduction of the pH and coagulation.

The reasons for fermenting milk are numerous. Although, the primary function is to extend its shelf-life, with added other advantage, like improving the taste of milk, enhancing the digestibility of the product and the manufacture of a wide range of products should not be overlooked. fermented milk may be defined as "*products to which other food substances may be added or not, obtained by pH decrease in milk or reconstituted milk, to which other lactic products may be added or not by lactic fermentation, through the action of specific microorganisms*"

The reasons for fermenting milk are

numerous. Although, the primary function is to extend its shelf-life, with added other advantage, like improving the taste of milk, enhancing the digestibility of the product and the manufacture of a wide range of products should not be overlooked. An historical survey of the origin(s) of fermented milk products (e.g. yoghurt, kefir, koumiss, sour milk) exhibits that they date back to rely civilisations around 10000 BC as the way of life of humans changed from food gathering to food gathering to food producing; this change also included the domestication of the cow, , buffalo, goat, sheep and camel. A wide range of indigenous fermented milk products are traditionally made in rural areas worldwide, and almost all of this products rely primary on spontaneous fermentation due to the presence of indigenous micro flora (mainly lactic acid bacteria) in the milk. In addition, it is safe to assume that the evolution of any given type of fermentation is dependent on the climatic condition of the region, so that while the thermophilic lactic acid fermentations became predominant in hot and subtropical countries because of the favourable growth conditions of the lactic cultures (40---45°C), mesophilic fermentations became more popular in colder climates, such as northern Europe. (Evdoinov, *et. al,* 2015, Carvohalo et. al., 2004)

Nowadays, most fermented milks are manufactured under controlled conditions with specified starter cultures, and the objective of this is to provide a general background to the evolution of these products, their properties and the patterns of their consumption in some selected countries. The health aspects attributed to special probiotic micro-organisms used in fermented milks and other dairy products.

Evolution of the process

Originally, the souring of milk was ununiform, and fermentations brought about by of lactic and non-lactic acid bacteria gave rise to products that were insipid and stale. Furthermore, the coagulam were often irregular, filled with gas holes and showed signs of whey syneresis. By contrast, pure cultures of lactic acid bacteria act on milk to produce a fermentate that is pleasant to eat or drink and, over the years, communities in different countries derived fermentation processes that brought the souring of milk´ under control. In particular, the process of yoghurt making included following as mentioned below:

- The use of the same vessel, or the addition of fresh milk to an ongoing fermentation, to ensure the build-up of a specific indigenous microflora(s) to sour the milk;
- Heating the milk over an open fire, increasing the solids content of the milk slightly, so yielding a more viscous coagulum due to the modified properties of the casein;
- Seeding of the processed milk at ambient temperature with sour milk from a previous batch, so enabling the thermophilic strains of lactic acid bacteria to become more predominant;
- A wise selection of lactic acid bacteria capable of tolerating high acidic conditions and giving the product its distinctive flavour.
- Heating of milk helped to eradicate any vegetative pathogenic micro-organisms present in the raw milk.

The production of fermented milk products became an established pattern of preservation, and science the early 1900s, defined micro-organisms have been used to prepare these products on a large industrial scale. Gradually, other communities learned of this simple preservative treatment for the milk, and defined products like yoghurt, cultured fermented buttermilk, kefir, koumiss and or acidophilus milk gained discrete identities. (Arab, *et. al*, 2016).

Various types of dried fermented milk products

Ksihk

Dried fermented milk products are popular in various parts of the world and can be important in diets of these countries. These products may be prepared for eating in different ways.

The nutritional and other properties of fermented milk products are well established (IDF, 1983-88; Renner. 1983, 1991; Scott, 1989), but limited information is available on traditionally made dried fermented milk products. A dried yoghurt-cereal mixture, known as Kishk is a popular product in the Middle East.

Kishk is a dried fermented milk/ cereal mixture which are being produced in many countries. Differences in the chemical composition of commercial and laboratory made samples are generally because of different ingredients have been used and the ratio of cereal to fermented milk ranges between 1:2 and 1:4.

Microbiologically, the product is free of coliforms, but may contain yeasts and moulds, depending on the hygiene during manufacture of the product. Sporeforming bacteria are the only organisms found in significant numbers.

Kishks made with cereals other than wheat are also of high quality but flavoured Kishks are not accepted by Middle Eastern consumers.

The product is highly nutritious and minor constituents that are deficient in milk are supplemented by cereal and vice versa.

Manufacturing process

The method employed for manufacture of Kishk may differ from one region to another because these processes are based on traditional systems. Milks from different species (cow, goat, sheep, buffalo and camel) have been used for the production of Kishk. For example Kishk from goat and buffalo milk is widely produced in Lebanon and Egypt respectively, while camel’s milk products are widespread in North Africa. Although the world milk’ is often used on Kishk-making, skimmed milk or the buttermilk from churned fermented milk is normally used. Kishk with a high fat content does not store well since it is prone to oxidative rancidity.

The cereal additive (i.e. parboiled cracked wheat) is known by different names such as Burghol, Bourghoul, Burghul or Bulgul. In the Lebanon, the method of preparation is as follows: soft wheat is cleaned of stalks, dirt and other cereal grains by using a rotory cylindrical machine which is known locally as ghorbal’. The same machine sizes the wheat kernels into three fractions: large, small and broken. The large grains are steeped in boiling water for 1 h until soft and then dried in the sun for 24 hours. On the following day, the dried grains are moistened with water (~20%), cracked and husked. The Burghol is separated from husk by winnowing and later sized as coarse or fine. It is recommended that coarse Burghol be used for Kishk-making.

Traditionally, Lebanese Kishk is made from goat’s milk and commercial production is as follows: - Milk is boiled, cooled and fermented using a starter culture ar the previous day’s yoghurt. The ratio of Burghol to yoghurt is 1; 4, and salt is added @ 6% (w/w). The yoghurt is added to the Burghol in small proportions for up to 6 days, and the mixture is kneaded daily. The temperature is maintained at ~35°C in order to complete the fermentation and achieve proper hydration of Burghol. Afterwards, the fermented milk-cereal mixture is formed into small balls or nuggets, placed on trays or concrete roofs and dried in the sun for 7-8 days. The dried Kishk is then milled to a powder at granaries and either packed into cloth, plastic bags or large bins.

Chemical composition

There are major differences in the chemical composition of commercial samples of Kishk made in different Middle Eastern countries: 3.9-13.7% moisture, 8.9-54.5% protein, 1.6-19.9% fat, 31.0-65.7% carbohydrates, 0.5-2.5% fibre and 3.8-9.5% ash. These differences are due to:

(a) Inherent differences between the traditional method of manufacture, and the efficiency of fat separation after churning the fermented milk;
(b) Some products being made exclusively from milk without addition of cereals and containing more than 35% protein;
(c) Different proportions of Burghol, fermented milk and salt;
(d) The use of strained yoghurt (~26%TS) rather than buttermilk (i.e. churned yoghurt ~10%TS) – addition of Burghol to fermented milk at the same ratio (1:4) will produce Kishk high in protein and low in carbohydrate;
(e) The use of different multiplication factors (6.25 or 6.38) to calculate the protein content in the product from the nitrogen content.

Nutrients value of Kishk

Kishk contains appreciable quantity of phosphorus (350-410 mg/100g), and the phosphorus content of most of the samples was similar to Burghol. The phosphorus content of Kishk is ~50% below that found in skimmed milk powder.

Kishk contains Ca of about 60mg/100g. Among the other elements, the concentration of iron in Kishk was significant (3-4 mg/100g) for a milk-based product.

The level of salt (NaCl) in Kishk varied between 1.0 and 8.4%; this variation is due to the addition of different amount of salt during preparation of product. The salt in Kishk is used as preservative and as a flavour enhancer, Since, Kishk is normally used to prepare a wide range of dishes, reduction in the salt level of this product may not be necessary because little or no salt will be added by the housewife.

Kishk may be a good source of certain B vitamins, but it is deficient in vitamin C and some fat soluble vitamins which are lost during manufacture. Niacin is the only vitamin whose concentration is ~3.5 fold higher in Kishk than in skimmed milk powder. This is due to: (a) the activity of microorganisms during fermentation of the milk (yoghurt starter culture actively synthesizes folic acid and niacin during fermentation of milk); and (b) the fact that Burghol also contains an appreciable amount of niacin.

The protein content of some types of Kishk is very high and hence the amino acid content is excellent. Kishk contents high concentration of phenylalanine, threonine, isoleucine, leucine, arginine, valine, tyrosine and lysine, but it has low amount of tryptophan and sulphul-containing amino acids.

Cultured buttermilk powder

Cultured buttermilk powder may be prepared from the high acid buttermilk using L*actobacillus bulgaricus.*

Food and Nutritive value

The sour/acid buttermilk powder is high in protein, lactose, minerals and also high in lactic acid.

Method of manufacture

Sweet buttermilk
↓
Pasteurization (82°C for 16 sec.)
↓
Concentration (up to 30% TS)
↓
Cooling to 46°C
↓
Inoculation (@ 1-5% lactobacillus bulgaricus)
↓
Agitation (to produce smooth curd)
(homogenization after incubation at low pressure will produce the same effect)
↓
Development of acidity to 10-12% in the dry product
↓
Spray drying (3.5-4.0% moisture)
↓
Cooling

Packaging and storage

Dried buttermilk is usually packed in Kraft paper bags with plastic (polythene liners or in fibre drums or without plastic liners. It is usually stored at room temperature.

Uses

High-acid cultured buttermilk powder is used for special purpose; under Indian conditions it may also be used for reconstitution into a lassi' beverage.

Freeze dried Dahi

Dahi is the most popular indigenous milk product of India which helps to preserve milk without refrigeration and other processing, but only by the way of fermentation. Dahi is more palatable, easily digestible and faster asssimilable in body in comparison with milk. On prolonged storage it becomes highly acidic. This makes dahi unfit for human consumption. Efforts to increase the keeping quality of dahi at room temperature have led to the development of dehydration techniques. Of the various drying methods, freeze drying has been thought to be suitable for dehydration of dahi.

Manufacturing process

Fresh buffalo milk
↓
Standardization (3to 6.0% fat)
↓
Homogenization
↓
Heating
↓
Cooling
↓
Inoculation (@1% mixed starter culture of *streptococcus lactic subsp*. diacetalactic and *streptococcus cremoris* in the proportion of 2:1 respectively in freeze dried state)
↓
Incubation at 37°C
↓
Cooling and storage at 5°C for 3-4 hours (formation of firm curd)
↓
Drying by freeze dryer (vacuum of 0.4 torr in the beginning and 0.1 torr at the end)
↓
Dahi powder
↓
Packing and storage (high density polyethylene bags).

Physic-chemical properties of freeze dried Dahi

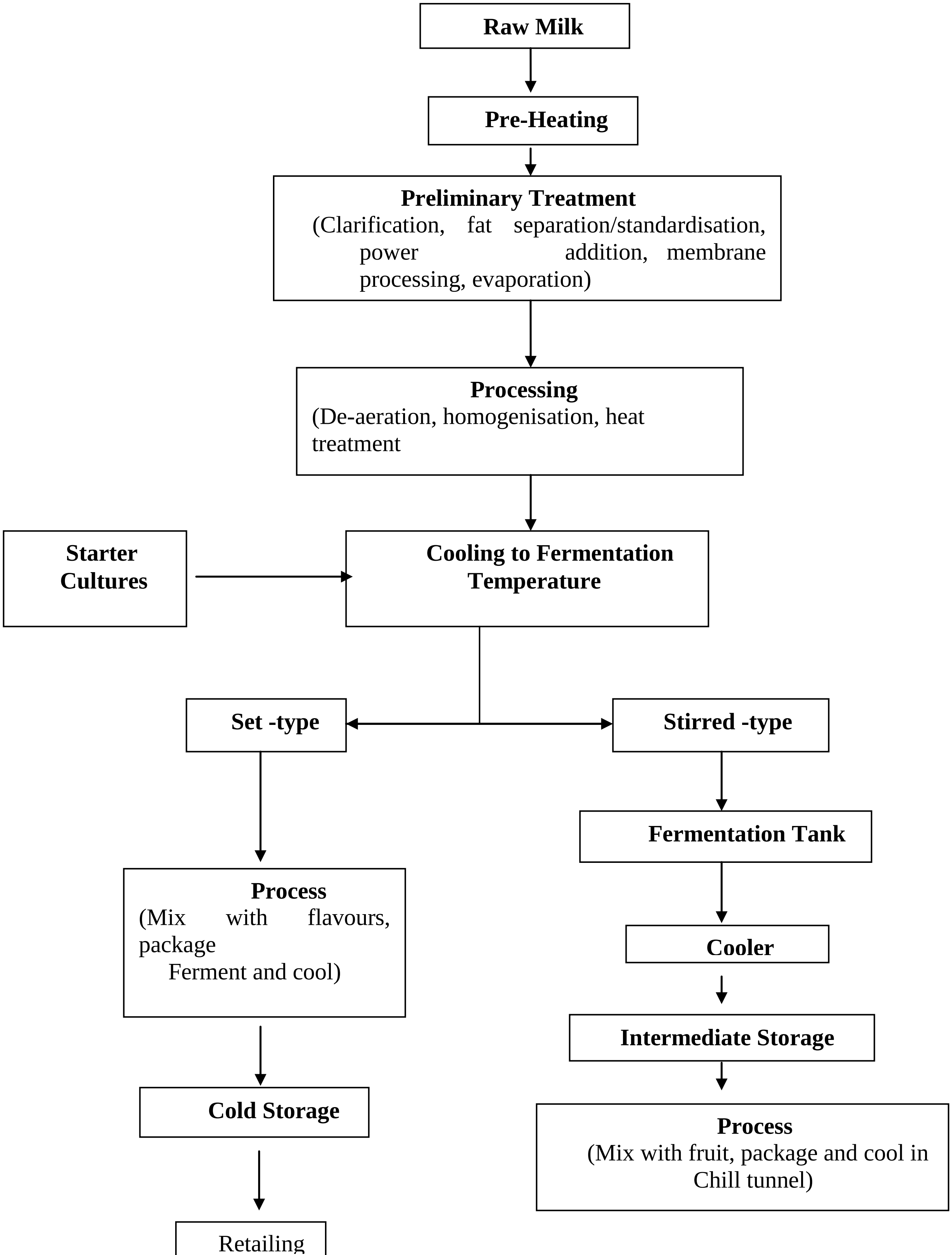
Fresh dahi and reconstituted dahi ((Baisya and Bose, 1974) were subjected to organoleptic evaluation to study its phisico-chemical properties. Phisico-chemical analysis of fresh dahi and reconstituted dahi was made with respect to its moisture, TS, pH, acidity, diacetyl, curde tension and viscosity.

It is evident from table-1 that the fresh Dahi was significantly superior over that of reconstituted freeze dried Dahi with respect to all parameters of organoleptic properties though, it rated as liked moderately. It is concluded that reconstituted Dahi may not be equal in overall quality to fresh Dahi, but acceptable among consumers. The less score obtained by reconstituted dahi may be due to its slightly dull white colour, losses of volatile compounds during freezing and drying of the product, in addition to destruction of gel structure, which resulted in non-uniform distribution of total solids and losses of smoothness and firmness. It can be observed from table-2 that there was increase in per cent acidity and decrease in pH of reconstituted dahi over that of fresh dahi because of higher solids content of freeze dried reconstituted dahi.

Broad Classification of Fermented Milks

Name	**Country of Origin**	**Microflora**
Acidophilus Milk	Australia	*L. acidophilus*
Yoghurt (Bioghurt	Middle Asia, Balkans	*S. salivarius* ssp. *thermophilus, L. delbreukii* ssp *bulgaricus,* *Micrococcus* and other lactic acid, cocci, yeasts, molds
Kefir	Caucasus	*L. lactis* ssp *lactis, Leuconostoc* spp. *L. delbreukii* ssp *caucasiucu, Saccharomyces kefir, Torula kefir, micrococci,* spore forming bacilli
Kumiss	Asiatic steppes	*L. delbreukii* ssp *bulgaricus, L. acidophilus, Torula kumiss,* *Saccharomyces lactis, micrococci,* spore forming bacilli
Dahi (*dadhi*)	India, Persia	*L. lactis* ssp *lactis, S. salivarius* ssp. *thermophilus, L. delbreukii* ssp *bulgaricus, plantarum*, lactose fermenting yeasts, mixed culture (not defined)
Shrikhand (*chakka*)	India	*S. salivarius* ssp. *thermophilus, L. delbreukii* ssp *bulgaricus*
Lassi	India	*L. lactis* ssp *lactis, S. salivarius* ssp. *thermophilus, L. delbreukii* ssp *bulgaricus*
Cultured Butter Milk	Scandinavian and European countries	*L. lactis* ssp *lactis, L. lactis* ssp *diacetylactis,* *Lueconostocdextranicum ssp citrovorum*
Leben, Labneh	Lebanon, Arab countries	*L. lactis* ssp *lactis, S. salivarius* ssp. *thermophilus, L. delbreukii* ssp *bulgaricus, plantarum*, lactose fermenting yeasts

A general flow diagram of all fermented milk products



Composition of high acid buttermilk powder

Characteristic	Requirement (%)
Moisture	4.8
Fat	5.7
Protein	37.6
Lactose	38.8
Ash	7.4
Lactic acid	5.7

Table.1 Score for organoleptic properties of Dahi

Qualities	Fresh Dahi	Reconstituted Dahi
Appearance	8.27	6.67
Flavour	7.92	6.82
Taste	7.92	6.77
Body	7.72	6.45
Acceptability	7.98	6.45

Table.2 Physico-chemical qualities of Dahi

Characters	Fresh Dahi	Reconstituted Dahi
Moisture (%)	83.84	79.44
Total solids (%)	16.16	20.86
pH	4.69	4.37
Acidity (%)	0.77	0.92
Diacetyl (mg/50ml)	11.13	8.13
Curd tension (g)	36.13	4.59
Viscosity (in Cp at 30 rpm)	919	150

The average composition of dried srikhand or srikhand powder

composition	Type of milk	
	Cow	Buffalo
Moisture	3.5	2.8
Fat	22.9	32.8
Total solids	96.5	97.2
Lactic acid	0.25	0.26

The significant reduction of diacetyl content of reconstituted dahi indicated that there is loss in diacityl content during the process and storage. The curd tension of reconstituted dahi was almost negligible and viscosity was very poor as compared to fresh dahi. The much reduction curd tension and viscosity of reconstituted dahi might be because of complete destruction of gel structure during drying process.

Srikhand powder

Srikhand is an indigenous Indian whole milk product prepared from lactic culture (dahi) and popular in western part of the country. The curd is strained through the cloth for several hours and solids obtained are kneaded with sugar to a buttery mass. This is called srikhand' and is used for direct consumption.

It is usually prepared under household condition. However, the preparation of srikhand is time consuming and a supply of a ready-to-reconstitute dried srikand.

Composition

The average composition of dried srikhand or srikhand powder is given below.

Food and nutritive value

Dried srikhand has a high fat content. It is expected to have a high protein and sugar (sucrose) content, a fairly mineral content, and also to contain appreciable amount of lactic acid.

Method of manufacture

Srikhand base (i.e. Chakka)

↓

Addition of goods grade ground sugar @ 18%

↓

Mixing by kneading

↓

Addition of water (20-25% of the mix)

↓

Stirring (to from smooth slurry)

↓

Homogenization (100kg/sq. Cm. Pressure)

↓

Spray drying
(Inlet air temperature=180-200°C outlet air temperature=100°C)

↓

Cooling

↓

Packaging (with or without gas packaging)

↓

Storage at room temperature

Packaging and storage

Srikhand powder may be packed in paper bags with polythene liners or fibre drums, with or without polythene liners, with or without gas packing, for storage at room temperature.

Keeping quality

Dried srikhand seems to have a marketable life of over 3 months at room temperature storage, when gas packed in hermetic containers.

Uses

The srikhand powder or dried srikhand is used for reconstitution into srikhand for direct consumption.

Spray dried acidophilus milk powder

In recent years, *Lactobacillus acidophilus* based products are available to the consumers in the form of cultured acidophilus milk products like acidophilus sour milk, acidophilus yeast milk, acidophilus paste and other related products. Due to the unpleasant flavour and taste these products were not accepted well. *L. acidophilus* the sole organism of the acidophilus milk product has the capacity of implantation in human intestinal tract and to antagonize the putrefactive and toxigenic organisms responsible for several gastrointestinal disorders in infants and adults. Recent studies have shown that the antagonistic action of *L. acidophilus* is due to antibiotic and not the acids elaborated during the course of fermentation. These antibiotic exhibited properties like bacteriostatic action against large number of gram positive and gram negative organisms, very acidic, very stable to heat(100°C for 15 min.) and long term storage at 4°C, but these properties are variable dependent on the growth and physical activity of the culture.

It is also available on the improvement of palatability milk products and the development of preparations like bioghurt, biogarde, acidophilus yoghurt and sweet acidophilus milk. But still there is a gap between various acidophilus milk products and consumer acceptance irrespective of excellent therapeutic value retained by these products. To bridge the gap efforts were made in the preparation of dried *L. acidophilus* products in the form of powder, capsules and tablets and the drying being carried out by lyophilyzation and by other techniques. Although, maximum viability of the dried cells is obtained when stored at -18°C or below in the absence of free oxygen but on the other hand the cells will no longer survive for a week when stored at room temperature. Still a dry product (even spray dried form of sour milk) would almost certainly be the preferable form if processing stability, storage loss and therapeutic value are protected.

Yoghurt powder

Yoghurt powders possess various nutritional and therapeutic values. Antitumour activity is associated with the cell wall of starter bacteria and so the activity remains even after drying.

The primary objective of drying yoghurt is to preserve it in a shelf-stable powdered form of high quality without a need for refrigeration. Such powder can be prepared by various methods, such as freeze-drying, spray-drying, microwave-drying and vacuum-drying. Before drying, it is beneficial to concentrate yoghurt by methods including cloth bag method, mechanical separation, and centrifugation, ultrafiltration and vacuum concentration. *Streptococcus thermophilus* shows less sensitivity in comparison to *Lactobacillus bulgaricus [L. delbrueckii subsp. bulgaricus*], during freeze-as well as spray-during of yoghurt. Cultured products sold with any claims of health benefits should meet the criteria of suggested minimum number of more than 10^6 cfu (colony-forming unit)/g at the expiry date. Freeze-dried yoghurt can be stored for up to 1-2 years at 4° C. After one year of storage, the powder typically contains total bacterial counts of 10^6 cfu/g. Active cultures are guaranteed for one year under cool, dry conditions for spray-dried yoghurt; it can be used in the bakery and confectionery industries.

Processing method

Basically, there are two methods of drying that could be employed commercially for the manufacture of dried yoghurt either spray drying or freeze drying and although, the freeze drying method of drying would seem to be more attractive- the temperature of drying (20-35°C) is much lower than that of spray drying (55-60°C) which eventually causing the least damage to the milk constituents and/or loss of flavour-it is far too expensive to be considered for commercial scale. However, a process for the manufacture of dried yoghurt with a pre-determined geometrical scale was reported in which the freeze drying is done at -30°C to -40°C. However, increasing the milk solids in yoghurt to 18.8g/100gTS resulted in an improved yield of freeze dried yoghurt form 0.22-0.31kg/sq.m.h, and a reduction in drying time per unit output of 25.8%; a further increase in the milk solids imparted a chalky taste to the dried product.

At present, powdered yoghurt is produced commercially using spray drying, but some precautionary methods should be considered. First, the concentration of yoghurt, before drying, should be carried out at 50-60°C and second, the drying conditions should be moderate to ensure a high viable cell count of *S. thermophilus* and *L. bulgaricus* in the dried product. In addition concentrating the yoghurt at higher temperature increases the scorching on to the surface to the evaporator and causes the discolouration in the final product. A scraped surface evaporator might also be used to concentrate the yoghurt before drying.

Both AVP and NIRO companies are leading drier manufactures and yoghurt can be dried in a three stage drying plant. The yoghurt is concentrated to 35g/100g TS, preheated and atomized to into the drying chamber with inlet and outlet temperature at 160 and 65°C, respectively. The semi-dried yoghurt particles fall down to the bottom of the drying chamber onto an integrated fluid bed drier; such particles form a fluidized layer which is further dried. Later, the powder is transferred to an external fluid bed drier for final drying and cooling. During drying, the product temperature is about 55°C and the powder outlet is at 25°C. Incidentally, the spent drying air form both drying chamber and the external fluid bed drier is drawn through the series of cyclones to recover the fine powder particles from the air. The fines are fed back to the external bed drier where they are mixed with the bulk of the powder to maximize the yield. Such type dried yoghurt contains 2g/100g moisture and has a tapped bulk density of 0.5g/cu.cm.

The microbial counts (cfu/g) in commercial dried yoghurt of non-lactic acid bacteria, *S. thermophilus and L. bulgaricus* were as follows: less than $1x10^4$, $1x10^3$, and $1x10^4$ respectively.

It has been reported by various workers that the survival rate of the yoghurt organisms was influenced by the processing conditions of the spray drier and they recommended that the product inlet feed temperature be at 30°C, the inlet and outlet temperature be at 160 and 60°C, respectively, the automising air pressure be at 98kPa and the hot air flow be 0.23cu.m/min. The survival rate of *S. thermophilus* was higher than *L. bulgaricus*, both showed similar survival patterns in freeze dried yoghurt powder.

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