The Pharma Innovation Journal 2022; SP-11(7): 4186-4190

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; SP-11(7): 4186-4190

www.thepharmajournal.com
Received: 01-04-2022
Accepted: 06-05-2022

Dr. Kiran Nagajjanavar
Assistant Professor, Department of Food Process Engineering, College of Horticultural Engineering and Food, Technology (UHSB), Devihosur, Haveri, Karnataka, India

Gurumurthy SB
Department of Food Process Technology, College of Horticultural Engineering and Food, Technology (UHSB), Devihosur, Haveri, Karnataka, India

Sharanabasava
Divison of Dairy Engineering, ICAR-National Dairy Research Institute, Karnal, Haryana, India

Chandan K
Department of Postharvest Technology, College of Horticulture, Sirsi, Karnataka, India

Shiddanagouda Yadachi
Department of Food Process Engineering, College of Horticultural Engineering and Food, Technology (UHSB), Devihosur, Haveri, Karnataka, India

Thippanna KS
Department of Food Process Technology, College of Horticultural Engineering and Food, Technology (UHSB), Devihosur, Haveri, Karnataka, India

Corresponding Author
Dr. Kiran Nagajjanavar
Assistant Professor, Department of Food Processing Engineering, College of Horticultural Engineering and Food Technology, Devihosur, Haveri, Karnataka, India

Yogurt: A review

Dr. Kiran Nagajjanavar, Gurumurthy SB, Sharanabasava, Chandan K, Shiddanagouda Yadachi and Thippanna KS

Abstract
Yogurt is a coagulated milk product and serves as an excellent source for the dietary incorporation of probiotic bacteria. In this review, the effort made to collect the history and origin of yogurt, the preparation method of yogurt, information of how the ice cream differs from frozen yogurt, and the role of each component in the processing of frozen yogurt is compiled for easy understanding about the yogurt.

Keywords: Frozen dessert, coagulated milk

1. Introduction
Yogurt is traditionally associated with a healthy image in both eastern and western cultures. (Perchonok & Bourland, 2002; Saxelin, M., 2008; Granato, D., 2010) [25, 31, 9]. Yogurt is a coagulum obtained by lactic acid fermentation of prescribed milk or milk products by the action of *Lactobacillus delbrueckii* subsp. bulgaricus and *Streptococcus thermophilus*, the addition of additives is voluntary. The product should contain more amounts of helpful microorganisms.

According to FAO/WHO (1977), it is a coagulated milk product obtained by lactic acid fermentation by the action of *Lactobacillus bulgaricus* and *Streptococcus delbrueckii* subsp. thermophilus, from milk Pasteurized milk or concentrated milk with or without optional additions (milk powder, skim milk powder, whey powder).

The origin of yogurt is not clear. According to some sources, yogurt originated in Asia, where the ancient Turks lived as nomads. The first Turkish name appeared in the 8th century as "Yogurt" and changed in the 11th century to its present form. According to still some authors, yogurt originates from the Balkans. The inhabitants of Thrace, known for breeding large flocks of sheep, used to make soured milk called "Prokish," which later became yogurt. Different types of yogurt are in many forms, such as asset, stirred, liquid/drinking, frozen, and dried/instant types.

Frozen yogurt is a functional food relatively new in the family of dairy foods and Frozen yogurt is a complex fermented frozen dairy dessert that combines the physical characteristics of ice cream with the taste and nutritional properties of fermented milk products (Rezaei, Rahil, *et al*. 2014; Soukoulis and Tzia. 2008; Jonkman *et al*., 1999) [29, 33,15]. Frozen yogurt gets its unique flavor from *Lactobacillus bulgaricus*, and *Streptococcus thermophilus* [Chandan, R. C *et al*. 1992] [3], and frozen yogurt is made in two forms: soft-serve hard frozen. Distributors frequently use the same mix in making both types (Loewenstein *et al*., 1979). Mainly include lactic acid bacteria that profit the health of consumers.

Frozen yogurt is a low acid product. It gets a unique flavor from strains of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* (Chandan, R. C *et al*. 1992) [3]. It is challenging to claim the authority to be the inventor of frozen yogurt. The history of frozen yogurt is relatively short, with its advent just three decades ago in 1970s New England. By the 1970s, ice-cream-making technology was transferred to frozen yogurt, a healthier, low-fat option for an icy dessert. It was not a huge success, though, because most Americans preferred the sweetness of ice cream over the tartness of the frozen yogurt flavor.

Frozen yogurt became a craze in the 1980s, but at the time, it could not rival ice cream as Americans' frozen treat of choice. Improvements in recipes and manufacturing technology change the consumer preferences have made the once-shunned tartness of frozen yogurt now craving many dessert-eaters. In 1989, frozen yogurt was the fastest-growing product in the frozen dessert category, increasing 300% from 1986.

The International Ice Cream Association reported in Dairy Foods that frozen yogurt accounted for about 5% of the $9.3 billion that Americans spent on frozen desserts (Jalón *et al*. 1989) [12]. Others estimate that yogurt sales in the US have reached $1 billion or more (Meydani & Ha, 2000) [20].
Due to its Nutritional properties, the product stems from the consumer interest in frozen yogurt (Chandan, RC, 1992; Marshall, RT, *et al*., 1997) [3, 18].

2. Process of frozen yogurt

Frozen yogurt is usually made from cow or buffalo milk or each combination. If it is made from goat milk, it has the same composition as frozen cow yogurt. (Loewenstein *et al.* 1979).
No federal standards for frozen yogurt have been established, but several states have definitions for frozen yogurt, including a minimum titratable acidity. Industry practice is to achieve a minimum titratable acidity of 0.30% (Chandan, R. C., 1992; Marshall, R. T., *et al*., 1997) [3, 18] with a minimum of 0.15% titratable acidity resulting from fermentation by yogurt bacteria (Marshall RT, *et al*. 1996) [18]. This treatable acidity may be achieved by fermentation with a mixture of *Lactobacillus delbrueckii* ssp. Bulgaricus (subsequently, *L. bulgaricus*) and *Streptococcus salivarius* ssp. thermophilus (subsequently, *S. thermophilus*) or standardization of the titratable acidity to the specified level by adding yogurt with ice milk mix. (Davidson *et al.* 2000) [5]
In preparing soft serve and complex frozen products, it is desired to have stable, attractive and smooth, and free from graininess (Tasneem *et al*., 2014) [36].
Frozen yogurt, exclusive of any flavouring, contains not less than 3.25 percent milk fat, not less than 8.25 percent milk solids, not fat, except that when bulky characterizing ingredients have been used, the percentage of milk fat is not less than 2.5 percent. The finished frozen yogurt shall weigh not less than five pounds per gallon. The treatable acidity of frozen yogurt is not less than 0.5 percent, calculated as lactic acid, except if the frozen yogurt's primary flavor is a non-fruit characterizing ingredient(s). The bacterial activity develops this characteristic acidity. No heat or bacteriostatic treatment, other than refrigeration, which may result in the destruction or partial destruction of the organisms, shall be applied to the product after culturing. On the label of frozen yogurt, the strains of bacteria may be collectively referred to as yogurt culture.

1) **Low-fat frozen yogurt Processing:** The food, exclusive of flavoring, contains at least 0.5% but not more than 2% milkfat and at least 8.25% milk solids, not fat, and has a titratable acidity of at least 0.3% expressed as lactic acid. This characteristic acidity is developed due to bacterial activity. No heat or bacteriostatic treatment, other than refrigeration, which results in the destruction or partial destruction of the organisms, shall be applied to the product after the culturing. Suppose the titratable acidity of the frozen yogurt mix is less than 0.3%. In that case, the manufacturer may establish compliance with this section by disclosing to the Department quality control records that demonstrate as a result of bacterial culture fermentation at least a 0.15% increase in treatable acidity, calculated as lactic acid, above the apparent treatable edge of the uncultured dairy ingredients in the frozen yogurt mix.
2) In addition to low-fat formulation, frozen yogurt supplemented with probiotic bacteria, such as *Lactobacillus acidophilus* and *Bifidobacterium longum*, provides additional health benefits. (Davidson *et al*. 2000) [5].
3) **Processing of non-fat frozen yogurt:** The food, exclusive of flavoring, contains less than 0.5% milkfat, not less than 8.25% milk solids, not fat, and has a titratable acidity of at least 0.3% expressed as lactic acid. This characteristic acidity is developed due to bacterial activity. No heat or bacteriostatic treatment, other than refrigeration, which results in the destruction or partial destruction of the organisms, may be applied to the product after culturing. Suppose the titratable acidity of the frozen yogurt mix is less than 0.3%. In that case, the manufacturer may establish compliance with this section by disclosing to the Department quality control records that demonstrate as a result of bacterial culture fermentation at least a 0.15% increase in titratable acidity, calculated as lactic acid, above the apparent titratable edge of the uncultured dairy ingredients in the frozen yogurt mix.

The label on a package of this food, in addition to all other required information, shall provide

a) Contain a complete list of ingredients according to 21 CFR 101.4 (relating to food; designation of ingredients).
b) Contain nutrition information as required by 21 CFR 101.9 (food nutrition labeling).
c) Comply with 21 CFR 101.22(h) and (i) relating to foods; labeling of spices, flavoring, colorings, and chemical preservatives).

3. How the frozen yogurt differs from yogurt and ice cream

The yogurt mixture was homogenized and incubated at 80 ºC for 30 min. After cooling down to 40 ºC, the starter culture was added. The fermentation was performed at 40oC for four h without shaking. After fermentation, the yogurt was stored at 4 ºC but for Frozen Yogurt. After homogenization at 4 ºC with the overrun (80%, v/v), the yogurt was frozen in a −3oC freezer. The total solid content was controlled at 36.5% (w/v). Aging was performed at −36 ºC for one day, then the frozen yogurt was stored in a freezer at −12~ −18 ºC for up to 6 months (Kim *et al*., 2009) [24].
The frozen yogurt environment is not optimum for the survival of bacteria. The cell count was less in the frozen yogurt because ice crystals negatively affected the bacterial viability (Davidson *et al*. 2000) [5]. The self-life of frozen yogurt is more while compared to yogurt. When frozen yogurt was compared with ice cream, Consumers often chose to eat frozen yogurt because they expected it to contain less lactose than ice cream with a similar amount of fat and provide health benefits from the viable bacteria. Compared to low-fat ice cream, frozen yogurt has an acidic flavor contributed primarily by lactic acid. Acetaldehyde, produced primarily by L. bulgaricus in the first 1 to 2 h of incubation, is the essential aroma compound in yogurt (Marshall *et al*. 1997) [18].

4. Role of components

In yogurt, the viability of the lactic acid bacteria is significantly affected by Ingredient supplementation [Dave and Shah, 1998]. The four main variables in the composition of frozen yogurt are fat, sugar, acid, and total solids. Dairy fat and total solids are the main determinants of textural quality, and sugar and acid contribute to flavor [Baer *et al*. 2002] [2].

According to Guinard *et al* 1994 [10]; Shoji *et al*. (2013) [32], sucrose is used to improve the sensory quality of food and as a nutrient by the lactic acid bacteria. The concentration of sweeteners in the product inhibits the growth of yogurt bacteria (Jimenez-Flores *et al*., 2006) [13].

Kim *et al* (2009) [24] attempted to find the effect of sucrose on the growth of the lactic acid bacteria. They found that the Addition of sucrose <3%, w/v before fermentation, increased the cell number by about 50% compared to the control. However, sucrose >5% (w/v) did not accelerate the bacterial growth but prolonged the fermentation period, probably due to the osmotic pressure.

The total solid content of milk whey increased the viability of the lactic acid bacteria [Oliveira *et al*., 2015] [23]. Carbonyl compounds, such as lactic and acetic acids, acetaldehyde, acetone, and diacetyl, result from lactose and proteins and contribute to sensory attributes in frozen yogurt (Chandan, R. C., 1992) [3].

The use of skim milk for yogurt fermentation has increased due to its low-fat content and improvement of the yogurt quality [Park *et al*., 2005] [24]. Similarly, Kim *et al* 2009 [24] Remeuf *et al*., 2003 also stated that the Addition of skim milk powder of 12% w/v resulted in a two-fold increase in the lactic acid bacterial cell number, improved the yogurt texture and flavor.

The statistical results obtained by Yate's algorithm indicated that the essential factors increasing the cell number were the skim milk and the ph. The Addition of skim milk at 12%, compared to 6%, increased the cell number by 0.48×109 CFU/g. In Addition, at pH 5.15, the bacterial growth increased to 0.47×109 CFU/g. (Kim *et al* 2009; Johansen *et.al* 2010) [24, 14].

Stabilizers reduce crystallization, hinder melting, and improve the handling properties of frozen yogurt (Baer *et al*., 2002) [2]. The stabilizing ingredients most used in frozen dairy foods are guar gum, locust bean gum (carob bean gum), CMC, sodium, propylene glycol alginates, xanthan gum, and gelatin carrageenan. Pectin is helpful in combination with the gums in sherbet and ices (Pinto *et al*., 2012). Typical emulsifiers utilized in frozen yogurt include monoglyceride, diglycerides, lecithin, polysorbate 80, and polysorbate 65 [Jiménez-Flores *et al*., 2006] [13]. In animal and vegetable gelatins, stabilizers are added to the frozen yogurt to maintain a smooth consistency in retail outlets, where temperature changes can coarsen the texture. The stabilizers also prevent the air bubbles from collapsing, promote good flavor release, and hold flavoring compounds in dispersion [Guinard JX *et al*., 1994] [10]. The percentage of stabilizers in the continuous phase of the final product is higher than the initial level because of freeze concentration. (Supavititpatana & Kongbangkerd, 2011) [35].

Moeenfard & Tehrani (2008) [21] investigated the effect of using some stabilizers on the viscosity, over-run, melting characteristics, and sensory properties of frozen yogurt. The ice cream mix in all groups was 10% fat, 13% sucrose, and 13% MSNF (milk non-fat solids). Stabilizers that were tried were Panisol ex (P), slab (s) and a mix of stabilizers and emulsifiers (M) include (sodium alginate (0.23%), guar (0.13%), carrageenan (0.05%), propylene glycol (0.48%), polysorbate80 (0.097%)) at concentrations 0.144, 0.198, 0.254%. No appreciable change was observed in the acidity and pH values of the products. Ice cream's viscosity, over-run capacity, and melting characteristics were influenced significantly (p<0.05) by the type and concentration of stabilizers. The samples' highest values for over-run and melting resistance include Panisol ex at 0.254%, and the lowest observed samples include salab at 0.144%. The sensory scores showed that yogurt ice cream produced using a mix of stabilizers/emulsifiers (M) at a concentration of 0.254% had the highest scores in texture. The type and concentration of stabilizers have no significant effect on the mouthfeel and flavor of samples.

In some studies, inulin was used as a fat replacer in yog-ice cream (El-Nagar *et al*., 2002) [6]. The addition of inulin increased the overrun of frozen yogurt (Rezaei *et al*., 2015) [29]. Overrun depends on the amount of air trapped in frozen yogurt and influences the quality of products (Moeenfard & Tehrani, 2008) [21]. Rezaei *et al*. (2015) [29] also examined the effect of inulin (0, 1and 2%) on some physicochemical properties of frozen yogurt, as well as its impact on flow behavior and probiotic survival, and reported that the addition of inulin improved overrun, viscosity and melting properties significantly (p<0.05) when added at 2% level, it also had a significant effect on pH. The total acceptability of samples revealed that frozen yogurt with 2% inulin had the most appealing sensory characteristics. In terms of probiotic survival, the sample with 2% inulin significantly improved the viability of *Lactobacillus acidophilus* and *Bifidobacterium lactis*. The acidity of yogurt also can be a harmful factor for probiotic viability (Muzammil *et al*., 2015).

5. Effect of process parameter

Probiotic microorganisms in aerated and frozen products such as ice cream and frozen yogurt can be injured when subjected to oxygen and freezing temperature. The freezing process of the mix may cause a loss of half to one log cycle in viable counts (Bair, 2002; Chandan, R C, 1992) [2, 3]. Rezaei *et al*., (2012) [30]. Moreover, the formation of ice crystals due to temperature fluctuations during storage may rupture bacterial cells and reduce viability (Davidson *et al*., 2000) [5]. The temperature change, causing ice crystal formation during the 6 to 12-month shelf-life, may rupture bacterial cells and reduce viability (Davidson *et al*. 2000) [5].

Kim *et al* 2009 [24] identified agitation caused clotting, deteriorated the texture of the yogurt, and delayed the growth of the lactic acid bacteria, probably due to the oxygen produced during agitation and the high amount of inoculum caused clotting in yogurt. Thus, the starter cultures maintained the inoculums at 0.01% (w/v).

The bacterial activity develops the characteristic acidity. No heat or bacteriostatic treatment, other than refrigeration, which may result in the destruction or partial destruction of the organisms, shall be applied to the product after culturing. According to applicable Sections of 2 NCAC 9B. 0016(f) (2) (21 CFR Part 101).

The contents of organic acids in yogurt during the fermentation and cold storage of yogurt continuously changed, and this affected pH of the yogurt during storage [Fernandez-Garcia *et al*., 1994] [7]. The lactic acid bacteria were sensitive to pH [Martin and Chou 1992] [19]. The maximum bacterial cell count was obtained at pH 5.0-5.5. The bacterial cell count decreased as the pH 5.0 decreased. Sung-Han Kim *et al*. 2009 [24] reported a decrease in pH after repeated freezing and thawing. The pH dropped from 5.5 to 4.9 after the second melting and 4.5 after the fourth meeting.

5. Role of Microbial quality of frozen yogurt

The shelf life of yogurt was strongly affected by the lactic acid bacteria cell number (108 lactic acid bacteria/ mL) [KFIO, 1995]. The cell number significantly decreases during storage and distribution due to the over-produced lactic acid [Sun and Griffiths, 2000] [34]. Therefore, proper control of yogurt production can prolong the shelf life. (Kim *et al*. 2009) [24]

The United States department of agriculture regulations that set microbiological requirements for frozen desserts applies to ice cream, ice milk, ice cream mix, and frozen yogurt that must meet the following phosphatase and coliform requirements: 7-03.2-09-02.

a. Phosphatase

The phenol value may be no greater than the minimum specified for the product as determined by the phosphatase test in the standard methods or other tests approved by the commissioner.

b. Coliform

1. In plain ice cream, ice milk, ice cream mix, and frozen yogurt products, the Coliform may not exceed ten per milliliter. Further, these products must not exceed twenty thousand per milliliter standard plate count.
2. In flavored ice cream, ice milk, ice cream mix, and yogurt products, the Coliform may not be more than twenty per milliliter. Further, these products must not exceed twenty thousand per milliliter standard plate count.

Frozen yogurt can serve as an excellent vehicle for the dietary incorporation of probiotic bacteria. Frozen yogurt supplemented with probiotic microorganisms provides additional health benefits (Davidson *et al*., 2000) [5]. The selection of traditional lactic acid starter bacteria in the culture with Bifidobacteria is vital to balance acid development and flavor (Davidson *et al*., 2000) [5]. However, these Bifidobacteria are sensitive to oxygen and acid, conditions found in frozen yogurt (Ravula & Shah, 1998) [27]. The viability of Bifidobacteria in the dairy medium is important because the value of the probiotic-supplemented dairy product depends on viable cells (Ishibashi *et al*. 1997) [11]. A minimum bacterial count of 107 CFU of Bifidobacterium/ml in fresh dairy products is recommended (Ishibashi *et al*. 1997) [11].

Recovery of injured cells in frozen yogurt is essential to determine the number of cells available to inhabit the intestine. (Davidson *et al*. 2000) [5]. Arany *et al*. (1995) [1]. Demonstrated that this method could recover injured Bifidobacterium from water and

Melted frozen yogurt inoculated with Bifidobacterium and L. acidophilus. This method provides an environment for cells to repair the injury and can be used as an alternative to conventional methods of recovery, which do not account for injured cells.

Rezaei *et al*. (2012) reported that in terms of probiotic survival, the sample with 2% inulin significantly improved the viability of *Lactobacillus acidophilus* and *Bifidobacterium lactis*.

Gidalar, Kitabi (2010) [8]. Studied the effect of blueberry on microbiological properties of yogurt ice cream; in this study, the impact of blueberry addition at five different ratios (0, 10, 20, 30, and 40%) and two varieties (wild and cultured) on the microbiological of yogurt-ice creams were examined at the first, 90 and 180 days. The decline in *Streptococcus salivarius* ssp. *thermophilus*, mesophylaerob bacteria, and coliform counts of yogurt-ice cream samples were observed due to increasing blueberry pulps ratios (p<0.05). Yeast and moulds were not significantly influenced by the addition of blueberry pulp and the frozen storage times (p>0.05). Microorganisms except Coliform survived during storage.

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