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A review on "Frozen yogurt smoothie"- An innovative functional food

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Abstract
Health foods are gaining popularity these days among which Smoothies are on top of the list. These are the fruit beverage that can be prepared based on consumers' preferences. Generally, Smoothies are defined as thick and creamy beverages prepared by blending various fruits, vegetables, juices, purees, seeds, dairy or non-dairy milk, etc. Even though smoothies are considered healthy foods they are often loaded with sugar which is the root cause of various life style diseases like cardiovascular diseases, obesity, diabetes, etc. Health benefits of yogurt can be increased by substituting yogurt with milk as it contains health-promoting bacteria which are good for intestinal and heart health. A cup of probiotics per day can maintain and improve the microbiome of the gut and prevent Dysbiosis, a condition that occurs due to a lack of gut-friendly bacteria in the intestine. Depending on the serving size and the total calorie intake, Frozen yogurt smoothies can be consumed as both snacks and breakfast. People of all ages can consume this functional food.

Keywords: yogurt, smoothie, probiotics, dysbiosis, microbiome, intestinal health

Introduction
Yogurt is a dairy product derived from bacterial fermentation of milk. The bacteria used to prepare yogurt is known as Yogurt culture which includes *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp *bulgaricus*, in addition to which other *Lactobacilli* and *Bifidobacteria* species are added if needed. Milk is converted to yogurt by the process of fermentation. Fermentation of milk sugar known as lactose by Lactic acid bacteria produces lactic acid, which acts on milk protein (Casein) and coagulates it. The key function of lactic acid is to act as a preservative and increase the shelf life of the product, and it gives yogurt its characteristic tart flavor, and texture and also increases the nutritional quality.
Probiotics are defined by Joint FAO and WHO (2001) as *"Live microorganisms which when administered in adequate amounts, confer a health benefit on the host"*. WHO also mentioned that to have positive health benefits from the consumption of probiotic foods, the microbes present in them should be abundant and viable during their processing, storage and transportation and also should be resistant to low pH as it has to come in contact with the gastric juice of the stomach and bile juice secreted by the liver.
Yogurt is a prime source of probiotics, as it contains living microorganisms and provide health benefits on consumption. According to Food Safety and Standards Authority of India (FSSAI) in order to call any food as Probiotics, the number of microbes present in it should not be less than 10^8 cfu/ ml or g. These are the helpful microbes that pass through the stomach and colonize the gastrointestinal tract and maintain the gut microbiome and also act against pathogenic bacteria. It prevents several diseases like diarrhoea, antibiotic-associated diarrhoea, helicobater pyroli, etc.
The word Probiotics is derived from two Greek words "pro" and "biotica" which means promoting life. The word probiotics is coined by lilly D.M and Stillwell R.H in 1965. Use of probiotics dates back many centuries ago but gained popularity when Elie Mechnikoff (20^{th} century) found that Bulgarians consume fermented milk on daily basis and on conducting several studies he concluded that consumption of fermented milk can prolong and improve the quality of life. Industrial-scale production of yogurt started in 1999 when Issac Carossa set up a large-scale commercial production unit of yogurt in Barcelona.
An imbalance in the microbiome of the gut leads to a range of ill health conditions like nausea, bloating, abdominal cramps, constipation, diarrhoea, etc. This condition is called Dysbiosis. Dysbiosis can be caused due to wide variety of reasons like autoimmune conditions, irritable bowel syndrome, antibiotic therapy, and also due to different lifestyle habits. Many studies have shown that the effective way to overcome this condition is by

consuming probiotics which can regain the quantity and quality of gut microbes lost and maintain intestinal health.

Preparation of Yogurt

Yogurt is a product obtained by fermenting partially evaporated milk with a special kind of bacterial culture that can produce lactic acid. Those bacteria used to produce yogurt are called "yogurt cultures". yogurt is obtained by fermenting the milk through the action of starter culture which contains *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. These bacteria ferment the milk sugar known as lactose converting it into lactic acid, which coagulates the milk protein and sets the yogurt to give it texture and its characteristic tangy taste. During fermentation Acetaldehyde, a flavor compound is also produced which gives yogurt its distinct flavor (Mohammad Tanzilur Rahman *et al.,* 2020) [26].

Skimmed milk is prepared by mixing 150g of skimmed milk powder with 850ml of distilled water, which gives approximately a liter of yogurt. Obtained skimmed milk is pasteurized at the temperature of 80-85°C for 15 mins and then it is cooled to the temperature of about 42-45°C. starter culture is added and mixed thoroughly and is allowed to ferment for 12 hours and then immediately kept in the refrigerator at 4°C to stop fermentation (Dhineshkumar and Ramasamy, 2016) [12].

Frozen yogurt is a frozen dessert made with yogurt, which is produced by bacterial fermentation of milk and sometimes by using other dairy products. Sometimes frozen yogurt may not be containing live bacterial culture like regular yogurt and its tartness varies compared to ice cream. Unlike yogurt, Ice cream is a frozen dessert that is typically made from milk and cream and doesn't contain any live microbes. The U.S. Department of Agriculture (USDA)'s Food and Nutrient Database for Dietary Studies (FNDDS), has categorized "yogurt" as food that includes "plain, flavored, and fruit-variety yogurt", but excludes frozen yogurt, which is classified into the food category "milk desserts" along with ice cream (An Ruopeng and Jiang Ning, 2017).

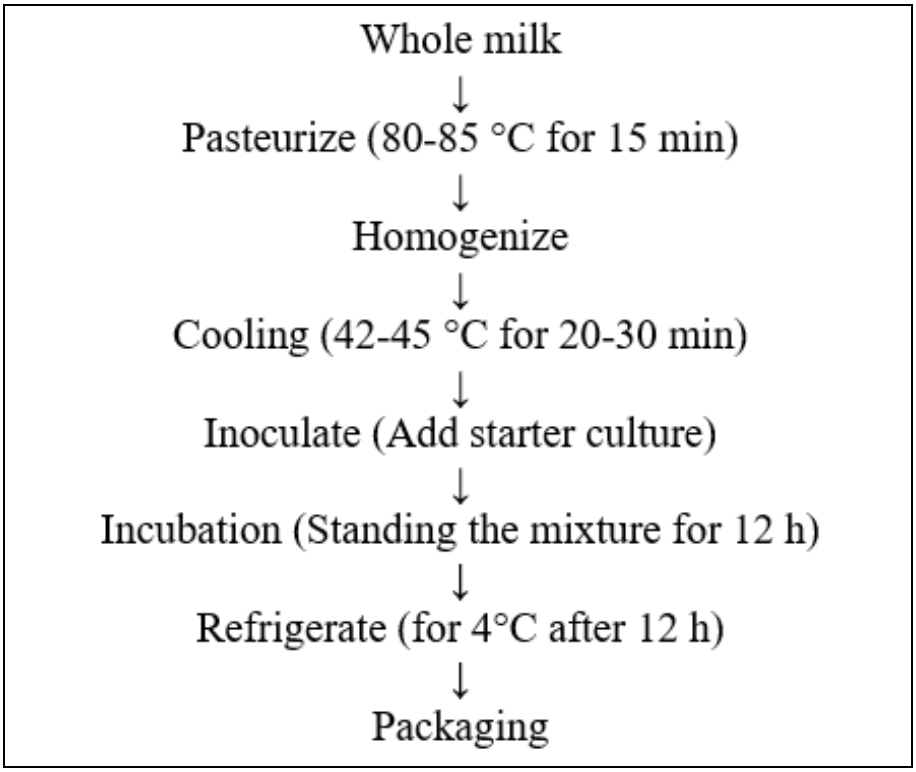

Fig 1: Flow chart for the preparation of Yogurt

Standardized Technologies for the Preparation of Frozen Yogurt Smoothie

Generally, for the preparation of fruit-based Frozen yogurt smoothies, fruits are washed, peeled, sliced, and frozen, those frozen fruits are blended in a blender along with sweetening agents like sugar/sucrose but preferably non-nutritive sweetener like stevia or fructooligosaccharides. After blending completely, either fresh yogurt or frozen unsweetened plain yogurt is added and blended again till a uniform mixture is formed, and is then transferred to a container and stored at -18°C allowing it to freeze. Any variation can be done to the smoothie by replacing fruit with vegetables, green leafy vegetables, puree, dry fruits, nuts, or any combination of these.

Fruit-flavored yogurt was prepared using mango and papaya. The ripened fruits were washed with water and then peeled aseptically using a knife. Fruit juices were extracted by a juice maker and homogenized using a homogenizer (POLYTRON, Switzerland). After that, both juices were filtered using clean cheesecloth and transferred to a sterile glass bottle, and stored in the refrigerator at 4°C. Yogurt was manufactured according to yogurt manufacturing procedures given by International Dairy Federation (IDF 1988). Fresh cow milk was used

for the production of yogurt. Raw milk was first filtered to remove foreign particles and then pasteurized at 72°C for 15 seconds to reduce the pathogenic microorganisms present in it then, the milk was cooled down to 42°C after that 3% of starter culture was added to pasteurized milk to prepare yogurt. Fruit juices (mango and papaya) kept in the refrigerator were brought to room temperature and then added to yogurt at the rate of 10%, 15%, 20%, and 25%. All variations were incubated at 42°C until complete coagulation of yogurt which takes about 5-6 hours. After complete coagulation, all treatments were cooled in the refrigerator at 4°C (Getenesh Teshome *et al*., 2017) [15].

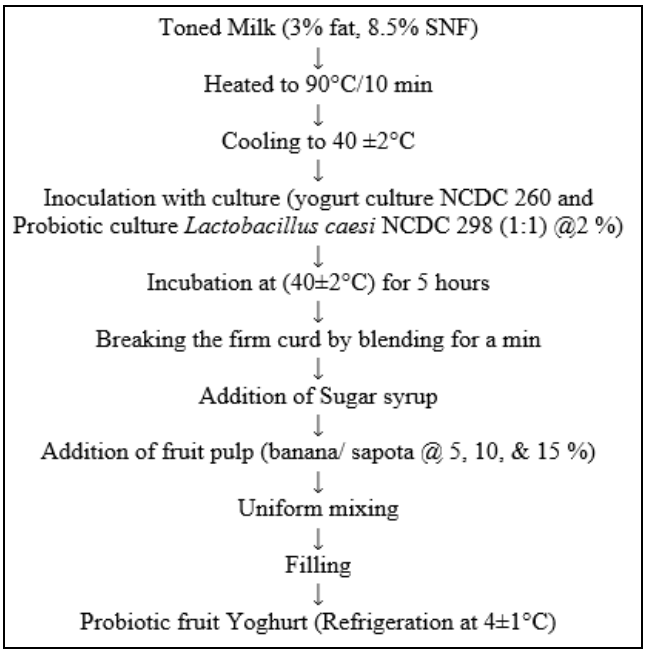

Fig 2: Flow chart for the production of probiotic fruit yogurt as given by Meenakshi *et al.,*

Fruit yogurt is prepared by heating whole milk in an open pan till its volume is reduced to one-third of its original volume. During heating, milk is constantly stirred to prevent the formation of a cream layer. After boiling 12% of sugar is added and is allowed to cool. Cooled milk at room temperature is divided into 4 equal parts in plastic cups. The fruit juice of pineapple, apple, and sweet lemon is added to 3 cups at the rate of 10, 20, and 30%, and no fruit juice is added to 1 cup which is used as control. After the addition of fruit juices, 2% of starter culture is added and is allowed to incubate at 37°C for 8-12 hrs until complete coagulation. All 4 samples were stored in the refrigerator at 4°C until used. Yogurt containing 5% apple juice was the best among all (Ritu Gangwar *et al*., 2016) [35]

Physicochemical Properties

Mariana Wolff De Carvalho *et al.,* have prepared 2 yogurt samples one with stevia and one without stevia and observed that the total solids in stevia fortified yogurt have increased compared to the one without stevia. It is also seen that during in-vitro gastrointestinal digestion both FRAP and ABTS assays have shown that the antioxidant value of stevia fortified yogurt has significantly increased and when stored in the cold condition it had a high count of yogurt culture i.e *Streptococcus thermophilus* and *Lactobacillus bulgaricus* throughout the storage period of 30 days. It is also suggested that yogurt can be used as a potential matrix to deliver bioactive components present in stevia.

Sapota fortified yogurt has shown high viscosity of 5200cP whereas control with no fruit has shown 4450cP and less syneresis (21.4) compared to control(30). Fruit-fortified yogurt has TSS of 16 compared to control (15). The protein and fat content of fortified yogurt is comparatively less, because of the lower fat and protein content of fruit compared to plain yogurt. Due to the acidic nature of fruit pulp, acidity value has increased. Thus it can be said that the final properties of fruit yogurt mainly depend on the type of fruit used. (Meenakshi *et al*, 2018)

Increasing the banana and pineapple content in smoothie increases the carbohydrate content in smoothies. In addition, it increased the energy value of smoothie, and fiber content ranged from 6.02 to 7.57% which helps in good bowel movement (Usunobun and Egharebv, 2004)

Strawberry juice yogurt was prepared by extracting juice from deseeded strawberries and then by filtering. Filtered juice was stored in a freezer at -20°C till mixed with sweetened yogurt (12%). Fruit juice was added at the rate of 0%, 5%, and 10% to the yogurt. Yogurt containing 5% fruit juice had a better acceptance level. (Mohammad Tanzilur Rahman *et al*, 2020) [26]

Table 1: Comparison of chemical components of yogurt with 0% and 5% are shown in the below table.

Chemical parameters	0% Fruit juice	5% Fruit juice
Moisture (%)	71.79	71.83
Total solids (%)	28.21	28.17
Fat (%)	4.72	4.35
Ash (%)	0.75	0.72
Acidity (%)	0.7	0.8
pH	4.48	4.0

As per the above table not much variation can be seen in almost all the parameters, the reason maybe is that they have used filtered fruit juice for flavoring, and filtration has removed the solid content in the fruit. Using different fruits like Banana, Pineapple, and Watermelon along with coconut milk has shown the varying amount of protein, carbohydrate, fat, fibre, ash, and moisture and it is also seen that pasteurization of smoothie doesn't affect much on nutritive content ($p>0.05$) (Uzodinma *et al.*, 2020).

Health Benefits

Dairy products provides wide range of nutrients, those who consume dairy-free and low-dairy diets are deprived of those nutrients, especially calcium, thus they fail to meet recommended daily intake of those nutrients and suffer from bone diseases etc. People who avoid dairy are the ones who are suffering from lactose intolerance, osteoporosis, weight management issues, rheumatoid arthritis and are attempting to avoid cardiovascular diseases. Thus they believe that health professionals can make them understand and include dairy products as a part of a balanced diet (Rozenberg *et.al).*

Irritable Bowel Syndrome

It is an intestinal disorder which is hypothised to be caused due to disturbed gut microbiome, however, the proper cause is yet to know. Analyzing the symptoms of IBS like pain in the stomach, diarrhoea and constipation, it is given the treatment of probiotics which normalized the levels of gut microbiota and stabilized it.

Whorwell *et al*., 2006, has conducted a study on female volunteers suffering from IBM. It is found that consumption of encapsulated Bifidobacterium infantis 35624 (1×10^8 cfu/ml) in the form of probiotics for 4 weeks has shown significant effects superior to placebo.

Lactose intolerance

It is a condition where a person is unable to adequately digest lactose, this is because of the deficiency of an enzyme called lipase in the small intestine which helps to digest milk sugar(lactose). people who suffer from lactose intolerance develop gastrointestinal symptoms upon consumption of dairy products. after effects of dairy products consumption by lactose intolerance person include nausea, abdominal cramps, bloating and diarrhea within 30 minutes to 2 hours after consuming milk or dairy products. The reason for symptoms is that there is no more lactase left in the gastrointestinal tract to digest the lactose consumed. Bacterial culture present in the yogurt act similar to the enzyme that is responsible for lactose digestion and aids in breaking down lactose in maldigestion (Daragh Hill *et al.*, 2017*)* [8].

Antibiotic-Associated Diarrhea

It is defined as having a watery stool more than three times a day while on antibiotic medication. 1 in 5 persons taking antibacterial medication will suffer from antibiotic-associated diarrhoea. Symptoms of AAD include more frequent bowel movements and loose stools. symptoms may be seen after a week of taking antibiotic medications. It varies most of the time as it can also be seen after stopping the medication.

Clostridioides difficile is a toxin-producing bacteria. It causes inflammation in the gut and reduces the number of healthy microbes in the gut. It is more severe than other antibiotics, along with loose stool and frequent bowel movements its symptoms also include mild fever etc. It can also spread from one person to another. Studies have shown that the consumption of probiotics that contain beneficial bacteria will help restore the bacteria in the gut during antibiotic medication and thus reduces the chances of diarrhea and also reduces the intensity of the symptoms.

Helicobacter Pylori Infection

It is a kind of bacterial infection caused by Helicobacter pylori on infecting the stomach. It is mostly seen in children. It is a communicable disease which spreads from one person to another through food, water, saliva, feces etc. It is commonly treated with different kinds of antibiotics and proton pump inhibitors.

H pylori can cause loss of appetite, nausea, burping, swelling, pain and irritation in the stomach and in case of severe infection it can cause stomach ulcers which can turn into cancer. Multistrain probiotics are used to treat H pylori infection and found that decrease in symptoms of the infection but not all the formulations were successful (McFarland *et al.*, 2016).

Conclusion and Future Perspective

The yogurt prepared by fermenting the milk using *Streptococcus thermophilus* and *Lactobacillus bulgaricus* species as starter culture is a probiotic food which helps in increasing and maintaining intestinal health by maintaining good amount of health-promoting bacteria in the gut and provides wide range of health benefits to consumers like decreasing the extent of antibacterial associated diarrhea and decreasing the symptoms of lactose intolerance on consumption of dairy products by people who are suffering from lactose intolerance. It also helps fight Helicobacter pylori infection, Irritable bowel syndrome, Necrotizing enterocolitis, Urogenital infection, Colon cancer, etc. The preparation of fruit smoothie using yogurt has additional health benefits based on the type of fruit being used, which are generally rich in dietary fibre, vitamins and various minerals and presence of antioxidants.

Yogurt has many beneficial effects on the consumer but the exact mechanism behind the effect is still unknown. The strains and doses used are based on the studies conducted and the results obtained. But it needs further *in vitro* and *in vivo* studies which can give clear picture of the mechanism of strain, the dosage needed etc... Multi-strain microbes are used in order to prevent and cure certain diseases, still that particular strain brings a positive effect on host is unknown and also the dosage of strains to be used for positive health benefits is also not set. Thus there is a lot of room for research on this topic. Due to the lack of regulation and legal definition for probiotics and its health benefits and the lack of a standard test for enumeration of probiotics, its market is still not fully invaded. Once the regulation is set we can have transparency about safety of the product and make health claims.

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