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An Update on Safety and Quality Concern of Frozen and Fermented Dairy Products: Control Strategies & Future Approach

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Abstract

The dairy industry is the premier part of the food industry producing a wide variety of products that are sold worldwide. The primary concern of the dairy industry is to deliver safe products due to the increase in the risk of pathogenic outbreaks associated with the dairy industry. It was found that most of the contamination occurs during manufacturing, handling, and storage operations. This review provides an update on the safety and quality concerns of frozen and fermented milk products, their control strategies, and future approach. Also, different microorganisms that act at various stages of operation in the production of frozen and fermented dairy products are described in this review. Therefore, it is a really important criterion to identify the root cause of the problem at every step of processing and preventive measures should be taken due to the growing risk with the increase in industrialization in the dairy industry.

Keywords

Frozen, dairy products, microorganisms, yogurt, ice cream

1. Introduction

The principal dairy frozen products include ice cream, frozen yogurt, frozen custard, ice milk, etc. Although, manufacturers and consumers have a positive image of frozen dairy products by considering them as microbiologically safe. But this does not eliminate the risk of pathogenic microorganisms and toxins transmission to the human body via frozen products [1]. Ice cream is the most popular frozen dessert sold worldwide. The basic steps involved in the manufacturing of ice cream are shown in Figure 1(a). The growth and multiplication of microorganisms are possible during various stages like production, storage, transportation, and marketing of these frozen products. The primary source of contamination can be water or raw milk. The secondary source of contamination includes tools that are used, flavoring agents, and handling [2, 3]. Various factors like inadequate utensils, machinery, time-temperature control, etc. may promote microbial growth in various food facilities [4].

Listeria monocytogens, Salmonella, Staphylococcus aureus, Pseudomonas, Bacillus, Streptococcus, Brucella sp., Campylobacter, Shigella, and coliform bacteria are some of the microorganisms that are generally present in these kinds of frozen products. Among them, coliform is mainly considered as a major post-pasteurization microbial contaminant. Some of these microorganisms are even harmful to human health and may lead to diseases like typhoid, cholera, bacillary dysentery [3, 5]. In the case of cooled raw milk, more than 90% of the total microbial population is of Psychrotrophic bacteria. Psychotropic microorganisms are mostly responsible for the spoilage of milk and milk products because they are capable of producing extracellular or intracellular Thermo resistant enzymes like proteases, lipases, and phospholipases [2, 6]. Microbial contamination in ice cream can take place at various stages of production, improper

handling, by adding the ingredients that are susceptible to contamination, tools and/or machinery, etc.

Fermented dairy products are rich in nutrients and produced by the action of specified lactic acid bacteria (LAB). This action by microorganisms results in pH reduction with or without coagulation. Streptococcus thermophilus, and Lactobacillus delbrueckii subsp. Bulgaricus, are common LAB strains used for the fermentation of dairy products in addition to probiotic bacteria such as Lactobacillus acidophilus (LA), Lactobacillus casei, and Bifidobacterium species [7, 8]. These microorganisms' cultures will be viable, active, and plentiful in the product to the date of minimum durability. Some fermented dairy products use yeast and mold with bacteria for the fermentation process such as kefir, koumiss, and viili. Yogurt, cheese, sour cream, buttermilk, kefir, koumiss, acidophilus milk, probiotic fermented milk, viili, etc are examples of fermented dairy products produced by using different LAB strains available in the market [8, 9].

The common health benefits related to fermented dairy products are improved lactose tolerance, protection against gastrointestinal infections, better immunity, effective treatment for a specific type of diarrhea in children, cholesterol reduction, enhanced mineral absorption, relief of constipation [9]. Yogurt is the most prevalent fermented dairy product consumed globally by all age groups [10]. The yogurt is classified as a set and stirred/drinkable based on physical nature; classified as regular, non-fat, low-fat based on fat content and some other yogurt types are Greek yogurt, frozen yogurt, flavored yogurt, fortified yogurt, etc. The yogurt manufacturing and processing conditions are shown in Figure 1(b). This section discussed the outbreaks, quality and safety issues, defects, standards, and control strategies associated with yogurt and other fermented dairy products.

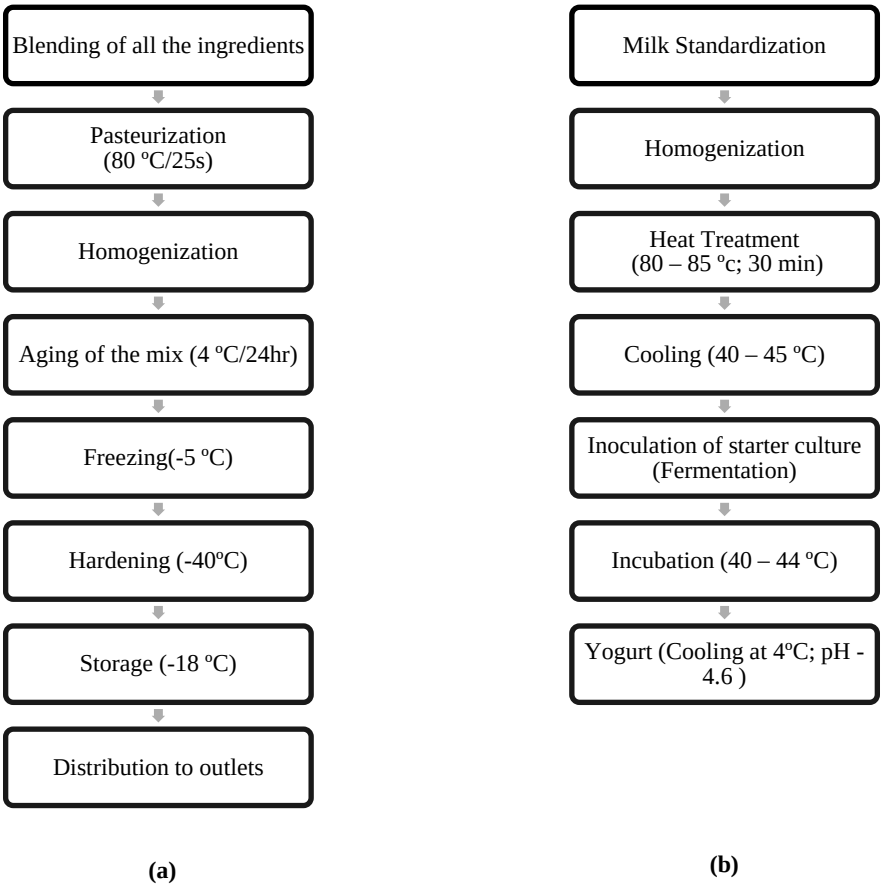

Figure 1. Manufacturing Process of (a) Ice cream (b) Yogurt.

In this study, we have discussed the most prominent microbes causing quality and safety issues, the various defects and their control strategies, outbreaks, and various standards for ice cream, yogurt, and other fermented product in different countries.

1.1. Most prominent microbes causing quality and safety issues in ice cream

Ice cream being a good source of nutritive value can also provide good media for the growth of microbes affecting the quality and safety of ice cream. However, steps like pasteurization, freezing, and hardening can eliminate the risk of

growth of microbial hazards. Pasteurization is the necessary step during ice cream production as it destroys pathogenic microorganisms, while freezing and hardening reduce the other potential microbiological hazards by exposing them to low temperatures. However microbial contamination is also possible post-pasteurization due to contaminated ingredients and improper handling. This is most common in the case of soft ice cream as it remains unsterilized during the final stage of production, therefore the microbial loads are difficult to control [11, 12]. *Listeria monocytogenes, Salmonella spp., Campylobacter spp., and Yersinia spp.* are some of the pathogens that can even survive at low temperatures. Although *Bacillus cereus* does not survive pasteurization, if the level of the number of *B. cereus* spores and there is inadequate time temperature control after pasteurization, it can cause illness [13].

In ice cream, post pasteurization contamination mostly occurs after adding various fruits, flavorings, nuts, raw milk, egg yolk, etc., and thereby microbes can easily be transmitted to the final ice cream. If adequate heat treatment is provided to the ice cream mixture, then raw milk is not considered as the source of microbial contamination. In fruits, yeasts (e.g., *Saccharomyces* and *Cryptococcus*), molds (e.g., *Alternia*, *Aspergillus*, *Botrytis*, *Fusarium*, *Geotrichum*, *Mucor*, *Penicillium*, *Rhizopus*), and bacteria (e.g., *Bacillus*, *Pseudomonas*, *Achromobacter*) are a potential source of contamination because of relatively low pH as it mainly promotes the growth of yeasts and molds. The microbial counts of fruits before freezing can effectively be reduced by adding hypochlorite to wash water. In the case of flavorings, ice cream can be contaminated by the action of Vegetative microbial cells and Bacterial spores. *Salmonella* spp. and *Micrococci* are the microbial groups that can cause contamination in ice cream via fresh eggs. However, the bacterial count can be reduced to a greater extent by pasteurization and freezing, microbes like *Bacillus*, *Micrococcus*, and *Enterococcus* may withstand freezing and pasteurization.

Several types of microorganisms that are isolated from ice cream were further described by various authors [14-16].

(a) Bacteria *Alkaligenes, Bacillus cereus, B. subtilis, Brucella abortus, B.melitensis, Cornybacterium diphteriae, Enterococcus faecium, E.faecalis, Enterobacter aerogenese, E. liquefaciens, Escherichia coli, Klebsiella, Micobacterium tuberculosis, Proteus, Pseudomonas, Salmonella, Shigella, Staphylococcus aureus, Streptococcus pyogenese.*

(b) Moulds *Absidia, Alternaria, Aspergillus, Fusarium, Mucor, Neurospora, Penicillium, Rhizopus.*

(c) Yeasts *Candida, Geotrichum, Rhodotorula, Saccharomyces.*

1.2. Most prominent microbes causing quality and safety issues in yogurt and other fermented dairy products

Despite several benefits, yogurt and other fermented dairy products can be contaminated with foodborne pathogens during processing, storage, and handling conditions. Mostly the pathogens are carried from untreated raw milk [17] or contaminated during processing and handling of the product. Fruits and other flavored ingredients may be another source of contamination associated with fermented dairy products [18]. This may lead to serious infections and diseases like scarlet fever, gastroenteritis, tuberculosis, diphtheria, etc [19].

Several factors affect the growth of pathogens in yogurt and other fermented dairy products. Untreated milk, fermentation process conditions (temperature and pH), poor sanitary conditions, improper manufacturing process, improper storage, and handling operations are some examples that affect the microbial quality of fermented dairy products. Coliform, yeast, and molds mostly indicate poor hygienic practices and improper heat treatments during the manufacturing and storage operations of fermented dairy products [17, 19]. Psychrophilic gram-negative bacteria, spore-forming gram-positive bacteria, Pseudomonas spp., and coliform are the source of milk spoilage after pasteurization [20]. Various articles reported Campylobacter jejuni, Salmonella sp, Escherichia coli O157:H7, Listeria monocytogenes outbreaks associated with bulk tank milk samples and dairy products [17, 19, 21]. Massa et al. [22] showed the survival of Escherichia coli O157:H7 in yogurt during 7-day storage at pH greater than 4.5.

The vital source of yeast contamination in flavored yogurt is untreated fruits and other additives, and improper storage. Yeast can grow at low temperatures and high acidic environment conditions. Another safety concern is the production of Aflatoxins due to mold growth on the yogurt surface. Mucor spp., Penicillum spp., Rhizopus spp., Aspergillus spp., and Alternia spp. are some familiar molds associated with yogurt and other fermented dairy products [18]. Another aflatoxin produced by Aspergillus species generally excreted by the mammary gland of the cow indicates toxicity for an animal [17]. Blanco et al. [23] showed the survival of aflatoxin produced by Aspergillus species during storage and manufacture of yogurt. Some other bacteria that affect yogurt quality are Lactobacillus delbrueckii subsp. Bulgaricus [18], Mycobacterium avium ssp. Paratuberculosis [24], etc.

To minimize and prevent the contamination of fermented dairy products, it is important to follow the proper heat treatment and fermentation process. The use of high-quality ingredients, pasteurized milk, and probiotic bacteria will help to improve the quality of a final product. Proper sanitization practices in the dairy plant before and after processing may help in reducing associated coliform, yeast, and mold contamination. Heat treatments of fruits and other additives also prevent the growth of yeast and molds in flavored products [18]. Proper storage and handling operations would help in preventing contamination after the manufacturing process. It is important to check for any microbial contamina-

tion routinely throughout the processing line and take the necessary steps to control it.

2. Defects and Control Strategies in Dairy Product

2.1. Frozen Dairy Product (Ice Cream)

Ice cream is a frozen dairy product where fat droplets, ice crystals, and air bubbles are dispersed in the matrix of sugar solution as a continuous phase in the form of colloidal dispersion. Stabilizers and emulsifiers are used in ice cream to improve its texture by enhancing its viscosity but the excess use of stabilizer and emulsifier may result in a lower melting rate and less whipping ability. Excessive sugar content results in an increase in solid content and an increase in solid content beyond a certain limit may result in defects like soggy structure. Fat also improves the physical, textural, sensory, and melting properties of ice cream but if fat content exceeds a certain desired concentration, it will result in destabilization and agglomeration of fat droplets and the faster meltdown of ice cream. The higher overrun results in shrinkage of structure. Therefore, to obtain good quality ice cream, composition control of all the ingredients is essential. Table 1 illustrates the various types of defects that occur in ice cream, the cause of the defect, and their control strategies.

Table 1. Defects and Control Strategies in Ice cream

Properties	Type of Defect	Cause of Defect	Control Strategies
Flavor	High/Low	Excessively/Inadequately flavored	Addition of correct amount of flavor
	Rancid	Lipase action in the high-fat content individual ingredients or the mix results in fat hydrolysis.	Proper pasteurization to inactive the lipase action.
	Bitter	Use of low-quality ingredients	Use fresh milk products and use real flavoring extracts.
	Acid/sour	Use of sour dairy products or due to inefficient cooling.	Use fresh and sweet dairy products, immediate and efficient cooling of milk, and storage of mix at 0-5ºC
	Cooked	Excessive heat treatment of ice cream mix during pasteurization.	Proper heat treatment during pasteurization.
	Flat	Addition of inadequate amount of sugar in the mix.	Add the correct amount of sugar.
	Oxidized/Metallic	Oxidation of fat occurs due to the direct contact of high-fat content ingredients or the ice cream mix with iron or copper. Exposure to Sunlight	Store the ice cream mix or its ingredients in aluminum alloy, tinned or stainless steel vessels.
Body	Crumbly	Inadequate stabilization, excessive overrun, and/or low total solid content in the mix.	Proper stabilization, optimum overrun, and optimum solid content in the mix.
	Soggy	High fat or sugar content, excessive stabilizer content, and low overrun.	Optimum fat or sugar content, stabilizer content, and overrun.
	Weak	Low stabilizer and solids content.	Optimum stabilizer and solid content.
Texture	Coarse/Icy	Low stabilizer and solids content, inadequate aging, slow freezing and hardening, heat shock.	Optimum stabilizer and solid content proper aging, proper freezing, and hardening avoiding heat shock.
	Fluffy	Excessive overrun, low solids content, and excessive emulsifier content.	An optimum amount of overrun, solids content, and emulsifier content.
	Sandy	High MSNF/ lactose content, heat shock, and the Long storage period	Optimum MSNF/lactose content, avoiding heat shocks and the short storage period
Melting	Curdy	Using high acid ice cream mix	Use fresh ice cream mix
	Foamy	Higher overrun and excessive emulsifier content	Optimum overrun and emulsifier content
	Slow melting	Inadequate homogenization and excessive stabilizer content	Adequate homogenization and optimum stabilizer content
Other	Shrinkage	Excessive overrun and temperature fluctuation during storage	Optimum overrun and maintaining the constant temperature.

2.2. Yogurt and other fermented milk products

Quality plays an important role in determining the consumer acceptance and satisfaction of the products. Quality attributes of yogurt and other fermented milk products can be defined based on physical, chemical, and sensory evaluation. The defects in the quality of the yogurt and other fermented milk are undesirable and unacceptable by the consumer. The common defects include the change in physical properties such as consistency, stability, body, and texture; change in chemical properties such as too high or too low pH, syneresis, gel strength, etc; change in sensory properties such as color, appearance, smell, flavor, etc [18]. Many factors are responsible for defects in fermented dairy products for example improper processing conditions (heat treatment, standardization, homogenization, incubation, cooling), usage of bad/spoilage ingredients (milk powder, milk, starter culture, fortification, stabilizers) improper handling, and storage of products (temperature) [25]. In addition, some studies showed the effect of vibration during transportation also affects the quality of fermented milk products. Protein network and fat globules bonds mainly described the physical structure of yogurt. To prevent defects in yogurt and other fermented milk products, it is advisable to follow specified processing, manufacturing, storage, and handling conditions. It could be better to check and taste all the ingredients; check the formulation and quantity required according to desired final product before starting the manufacturing [25]. Some of the common defects, their types, sources, causes, and control strategies are mentioned in Table 2.

3. Outbreaks

Dairy products are the main concern for the dairy industry and the health authorities [26], as they can result in various outbreaks or incidents due to foodborne pathogens [27]. Many authors in their study reported the outbreaks or cases of foodborne illnesses due to dairy products [28-34]. 2% to 6% of outbreaks or incidents of foodborne illnesses in industrialized countries are due to milk and dairy products [35]. Several authors had reported the food-borne disease outbreaks in Europe and North America [36-38] due to consumption of ice cream [39]. *Listeria monocytogenes, Salmonella, Escherichia coli* O157:H7, and *Campylobacter jejuni* are the pathogens that are typically responsible for the outbreak due to the consumption of ice cream.

4. Standards

Standards for ice cream are mostly defined by its milk fat content, milk protein content, total milk solids, and total solid content. To produce the ice cream of good quality, it is important to obtain the ingredients of good hygienic quality which will satisfy the physical, chemical, and bacteriological standards prescribed for the finished products. Goff and Hartel [40] in their study have reviewed the minimum standard compositional limits for some of the major ice cream producing and consuming countries outside of the European Union as shown in Table 3.

A UK-based industry (The Ice Cream Alliance) has set out its limits on a minimum quality standard for ice cream [41]. For them, a minimum of 5% fat and not less than 2.5% milk protein should be present in the final product.

There are different standards for yogurt and other fermented dairy products according to different countries. The standards are mainly expressed in terms of milk fat content, titratable acidity, milk protein content, starter culture amount, active and live culture content added as a supplement to starter culture. According to the US Food and Drug Administration (FDA), all ingredients used for manufacturing yogurt and other fermented dairy products should be safe and suitable. The milk solid-not-fat content (MSNF, expressed as a percent) and titratable acidity (TA, percent expressed as lactic acid) for all regular, low-fat, and non-fat yogurt are similar whereas the milk fat content (MF, expressed as a percent) differs based on yogurt type. The MSNF and TA for all yogurt types should not be less than 8.25 percent and 0.9 percent expressed as lactic acid, respectively. The MF content for regular, low-fat, and non-fat yogurt are not less than 3.25, not less than 0.5, and not more than 2, less than 0.5 percent respectively (21 CFR Part 131.200, 131.203, 131.206) [42-44]. For acidified and cultured milk, MF content is not less than 3.25 percent, MSNF content is not less than 8.25 percent, and TA of not less than 0.5 percent is expressed as lactic acid, respectively (21CFR part 131.111, 131.112) [45, 46]. In addition, the food may be homogenized and shall be pasteurized or ultra-pasteurized before the addition of the microbial culture. For flavoring all the yogurt types, it is advisable to add flavoring ingredients after pasteurization or ultra-pasteurization. To extend the shelf life of the food, all yogurt types may be heat-treated after culturing is completed, to destroy viable microorganisms.

Although, according to Codex Standard for fermented milk (CODEX STAN 243-2003) [47], the minimum TA of 0.6% as lactic acid is advisable for yogurt and acidophilus milk. The compositions (milk protein, milk fat, TA, ethanol, viable microorganisms, and yeast) guidelines for fermented milk, yogurt, alternative yogurt culture, acidophilus milk, kefir, and kumys are shown in table 4. The microbiological criteria (based on the proportion of fermented milk products) are valid up to the date of minimum durability. This requirement does not apply to products heat-treated after fermentation.

Table 2. Defect and Control Strategies Associated with Yogurt and Other Fermented Dairy Products

Properties	Defect Type		Sources and Causes	Control Strategies
Sensory	Organoleptic (aroma/flavor)	Production of carbonyl compounds/ metabolic activity (*Lactobacillus delbrueckii* subsp. *Bulgaricus)*	Improper incubation temperature, improper inoculation level of starter culture, bacteriophage activity	Recommended incubation temperature (41-43 ºC); inoculation of starter culture (2.5-3.0 %).
		Sourness	Too fast and too slow cooling, improper storage condition, high inoculation level of starter culture, low fat, and protein content	Use a two-step cooling process, store at refrigeration temperature (4ºC), use recommended starter culture inoculation level.
		Cooked	High heat temperature causes recurrence of sulfhydryl groups	Heat treatment (80-85ºC; 30 min or 90-95ºC; 10 min)
		Bitterness	Old or spoiled ingredients, high temperature	Use fresh, high-quality ingredients and taste before production, handle at proper processing and storage temperature conditions.
		Rancid	Mixing of pasteurized and unpasteurized products, activation of lipase enzyme, excessive blending/mechanical agitation before pasteurization	Pasteurize product to inactivate lipase enzyme, avoid excessive blending.
		Metallic	Use of metal container during processing	Replace metal with stainless steel containers.
		Atypical	Excess use of potassium sorbate and other cleaning/sanitizing agents	Replace potassium sorbate with sorbate or heap-filtered fillers.
		Malty	presence of yeast/molds	Maintain sanitizing conditions during processing.
	Appearance/ Color	Atypical (undesirable or not represent the specified flavor)	Use of low-quality fruits, color, flavoring, fortified agents, improper storage condition	Use of good quality fortified/flavoring ingredients, proper storage of final products
		Dry surface	Evaporation of water during improper storage conditions (too cold)	Store product at specified storage condition (4ºC), use of good quality packaging material.
		Lumpy	Improper stabilization, agitation, smoothening, and filling of products (improper temperature and pH).	Use of adequate amount stabilizers and two-step cooling process (21ºC and < 7ºC), proper agitation, and mixing of products/additional favored produced
		Heterogenous color/fruits distributions	Presence of too little or too many fruits/flavored products, growth of yeast/molds due to high storage temperature	Add an adequate quantity of flavoring agent/fruits to products, store the final product at desired conditions, and maintain proper cleaning /sanitization during product manufacture.
		Presence of Bubble	Contamination with coliforms	Discard the products and sanitize the processing plant.
Physio-chemical	Body and texture	Whey off/free whey/syneresis	Excessive agitation, improper pH, improper processing and storage temperature condition, inappropriate manufacturing result in translucent green liquid on top or around the sides of a yogurt cup.	Proper handling and maintain the processing steps and storage conditions
		Weak	Inappropriate standardization, excessive heat treatment, and agitation results in too runny final products	Balance the total solid contents and maintain the proper heat treatment and agitation.
		Grainy	Improper heat treatment, low pH, improper mixing of starter culture	Use of specified conditions to make final products.
		Ropy	Inadequate use of stabilizers, improper setting temperature, microbial contamination, too high sugar content in the base,	Check product formulation and maintain specified temperature conditions.
		Shrunken	Heat shocks, usage of inadequate stabilizers, high acidification, disturbance while settling of products result in a gap between yogurt and cup	Identify the actual cause and store the yogurt at a specified temperature. Do not disturb the yogurt while knitting.
		Too firm/Gel-like	Addition of too much skim/casein powder to the base, improper usage of stabilizers.	Use the correct and proper amount of stabilizer and powder.

Table 3. Percent composition standard limits major ice cream producing and consuming countries

Country	Milk fat (%)	Milk protein (%)	Total milk solids (%)	Total solids (%)	Food solids per litre (g)	Weight per litre (g)
Australia	10	_a	-	-	168	-
Brazil	3[b]	2.5	-	-	152	475
Canada	10	-	-	36	180	-
United States	10		20		192	540
New Zealand	10	-	-	-	168	-

[*]Source: Modified from Goff and Hartel (2013) [40]
[a] Not specified
[b] Minimum total fat is 8%, the balance can be comprised of non-dairy fat

In addition, concentrated fermented milk such as Stragisto (strained yogurt), Labneh, Ymer, and Ylette has a minimum of 5.6 percent protein content, which can be increased before or after the fermentation. Flavored fermented milk is stated as "composite milk products which contain a maximum of 50% (m/m) of non-dairy ingredients (such as nutritive and non-nutritive sweeteners, fruits, and vegetables as well as juices, purees, pulps, preparations and preserves derived therefrom, cereals, honey, chocolate, nuts, coffee, spices, and other harmless natural flavoring foods) and/or flavors. The non-dairy ingredients can be mixed in before/or after fermentation" (CODEX STAN 243-2003) [47].

Table 4. Codex Standards for Fermented Milk Products

	Fermented Milk	Yogurt, Alternate Culture Yoghurt and Acidophilus milk	Kefir	Kumys
Milk protein[(a)] (% m/m)	min. 2.7%	min. 2.7%	min. 2.7%	
Milk fat (% m/m)	less than 10%	less than 15%	less than 10%	less than 10%
TA, as % lactic acid (% m/m)	min. 0.3%	min. 0.6%	min. 0.6%	min. 0.7%
Ethanol (% vol./w)				min. 0.5%
Sum of microorganisms. constituting the starter culture defined in section 2.1 (cfu/g, in total)	min. 10^7	min. 10^7	min. 10^7	min. 10^7
Labelled microorganisms[(b)] (cfu/g, total)	min. 10^6	min. 10^6		
Yeasts (cfu/g)			min. 10^4	min. 10^4

[(a)] Protein content is 6.38 multiplied by the total Kjeldahl nitrogen determined.
[(b)] Applies where a content claim is made in the labeling that refers to the presence of a specific microorganism (other than those specified in section 2.1 for the product concerned) that has been added as a supplement to the specific starter culture.
Source: Codex Standards of Fermented Milks (CODEX STAN 243-2003) [47].

5. Future Approach

There is scope for further improvement in the ice cream manufacturing field to meet changing demands of consumers. There is a need to pay more attention to post-pasteurization contamination. To ensure safety, the public and the trade must be advised to pay adequate attention to some key areas from the preparation to the consumption of ice cream to ensure complete safety and minimize outbreaks of food-borne illness. More emphasis should be given to the implementation of HACCP in milk processing units from a food safety point of view.

The use of proper ingredients along with proper manufacturing operations would lead to better quality final products. In the future, additional studies related to controlling and eliminating emerging pathogens can be possible. Nowadays people are more health-conscious, focused on improving the quality of yogurt fortified with protein and influencing protein digestibility. The use of new innovative technologies such as high-pressure processing, membrane processing

would help to improve the safety and quality of yogurt and other fermented dairy products. This might be able to help in more controllable and predictive milk fermentation that can further in improved quality and safety. Packaging of fermented dairy products is an important factor to prevent contamination. Smart and environment-friendly packing could be a better option for fermented dairy products. This would guide the consumer about the products and their safety concerns.

6. Conclusions

The production and consumption of ice cream are increasing every year and as the ice cream is consumed by people of all age groups, the possibility of foodborne illness by children, elderly people, and immunosuppressed patients from the frozen dairy products cannot be ignored. All the hygienic and microbiological aspects must be critically monitored during the manufacture of ice cream. Improper heat treatment, inadequate homogenization, excessive overrun, excessive stabilizer, or emulsifier content can affect the quality and safety parameters of ice cream. Before freezing, the ice cream mix should be subjected to proper heat treatment to ensure food safety thereby eliminating the risk of survival of pathogenic microorganisms. This will certainly help to improve the quality, increase the shelf life and ensure the safety of the product.

Yogurt and fermented dairy products are beneficial to human health. However, there can be a risk of contamination during manufacturing, storage, or handling operations. Improper heat treatment, improper fermentation, improper cooling, improper storage, the unhygienic condition could affect the safety and quality of fermented dairy products. To avoid defects and microbial contamination, it is important to follow specific guidelines and sanitization steps during product manufacturing, storage, and transportation. To avoid mold and yeast contamination, maintain the proper sanitization throughout the manufacturing operations. Check the milk, milk powder, starter culture, fruits, stabilizer, and other additives to minimize the sensory and physical defects. It is necessary to identify and understand the root cause of the problem affecting the quality and safety of fermented dairy products. Then accordingly work on eliminating/controlling the issue by following guidelines or applying new innovative techniques to overcome the problems.

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References

[1] Marshall, R. T. and W. S. Arbuckle. (2000). Ice Cream. 5th edition. Aspen Publishers, Gaithersburg, Maryland, USA.

[2] Mokbul Mansura, Islam Tazul, and Alim Sharmin Rumi. (2016). Bacteriological Quality Analysis of Ice Cream Produced by the Small Factories of Dhaka City. International Journal of Health Sciences and Research, Vol. 6, Issue: 12, 235-240.

[3] Ahmed Khalil, Hussain Azhar, Imran, Qazalbash Mudassier Ali, and Hussain Wajid. (2009). Microbiological Quality of Ice Cream Sold in Gilgit Town. Pakistan Journal of Nutrition, 8(9): 1397-1400.

[4] Gould, L. H., Rosenblum, I., Nicholas, D., Phan, Q., and Jones, T. F. (2013). Contributing factors in restaurant-associated foodborne disease outbreaks, FoodNet sites, 2006 and 2007. Journal of Food Protection, 76, 1824-1828. 10.4315/0362-028X.JFP-13-037.

[5] Windrantz, P. and Arias, M. L. (2000). Evaluation of the bacteriological quality of ice cream sold in San Jose, Costa Rica. Archivos Latino Americans De Nutrition, 50(3): 301-303.

[6] Jawdat Fadihl, S., Qassim Mohammad, S., and Muafaq Al-qrtani, Y. (2019). Microbiological evaluation of locally produced ice cream in Baquba city. Iraq. Journal of Physics: Conference Series, 1294, 062057. https://doi.org/10.1088/1742-6596/1294/6/062057.

[7] Granier, A., Goulet, O., and Hoarau, C. (2013). Fermentation products: Immunological effects on human and animal models. Pediatric Research, 74(2), 238-244. https://doi.org/10.1038/pr.2013.76.

[8] García-Burgos, M., Moreno-Fernández, J., Alférez, M. J. M., Díaz-Castro, J., and López-Aliaga, I. (2020). New perspectives in fermented dairy products and their health relevance. Journal of Functional Foods, 72(April), 104059. https://doi.org/10.1016/j.jff.2020.104059.

[9] Buttriss, J. (1997). Nutritional properties of fermented milk products. International Journal of Dairy Technology, 50(1), 21-27. https://doi.org/10.1111/j.1471-0307.1997.tb01731.x.

[10] Eroglu, A., Bayrambas, K., Eroglu, Z., Toker, O. S., Yilmaz, M. T., Karaman, S., and Dogan, M. (2016). Steady, dynamic, creep/recovery, and textural properties of yoghurt/molasses blends: Temperature sweep tests and applicability of Cox-Merz rule. Food Science and Technology International, 22(1), 31-46. https://doi.org/10.1177/1082013214566478.

[11] Leisnter, L. and Gould, G. W. (2002). Hurdle technology. New York, NY: Kluwer Academic Publishers.

[12] Park, J. M., Kim, J. M., Hong, J. W., and You, Y. H. (2020). Microbial control measures for soft ice cream in franchise brands: A comparative analysis of microbial analysis and manufacturing practices. Food Science & Nutrition, 8(3), 1583-1595. https://doi.org/10.1002/fsn3.1446.

[13] Ghoddusi, H. (2014). Microbiology of Cream, Butter, Ice Cream, and Related Products. In B. Özer (Ed.), Dairy Microbiology and Biochemistry (1st ed., pp. 245-270). Taylor & Francis. https://doi.org/10.1201/b17297-11.

[14] Ikenebomeh, M. J. and Ogaguvia, R. A. (1993). Microbiology from ice cream. Nigerian Journal of Microbiology, 9: 40-46.

[15] Sherikar, A. T. and Majee, S. B. (2004). Microbiology of milk and milk products. In Textbook of Elements of Veterinary Public Health. Eds by A. T. Sherikar, V. N. Bachhil, and D. C. Thapliyal. Indian Council of Agricultural Research, New Delhi, India.

[16] Ojokoh, A. O. (2006). Microbiological examination of ice cream in Akurue. Pakistan Journal of Nutrition, 5: 536-538.

[17] Rad, A. H., Javadi, M., Kafil, H. S., Pirouzian, H. R., and Khaleghi, M. (2019). The safety perspective of probiotic and non-probiotic yoghurts: A review. Food Quality and Safety, 3(1), 9-14. https://doi.org/10.1093/fqsafe/fyz006.

[18] Ozer, B. and Kirmaci, H. A. (2010). Quality attributes of yogurt and functional dairy products. CRC Press, Boca Raton, FL.

[19] Olivier, S. P., Jayarao, B. M., and Almeida, R. A. (2005). S. P. OLIVER, 1 B.M. JAYARAO, 2 and R.A. ALMEIDA 1. Foodborne Pathogens and Disease, 2(2), 115-137.

[20] Martin, N. H., Boor, K. J., and Wiedmann, M. (2018). Symposium review: Effect of post-pasteurization contamination on fluid milk quality. Journal of Dairy Science, 101(1), 861-870. https://doi.org/10.3168/jds.2017-13339.

[21] Agu, K. C., Archibong, E. J., Anekwe, D. C., Ago, C. A., Okafor, A. C., and Awah, N. S. (2014). Assessment of Bacteria Present in Yoghurt Sold on Awka Metropolis. Scholars Journal of Applied Medical Sciences (SJAMS), 2(6D), 3071-3075. www.saspublisher.com.

[22] Massa, S., Altieri, C., Quaranta, V., and De Pace, R. (1997). Survival of escherichia coli O157:H7 in yoghurt during preparation and storage at 4°C. Letters in Applied Microbiology, 24(5), 347-350. https://doi.org/10.1046/j.1472-765x.1997.00067.x.

[23] BLANCO, J. O. S. E. L., DOMÍNGUEZ, L. U. C. A. S., GÓMEZLUCÍA, E. S. P. E. R. A. N. Z. A., GARAYZABAL, J. O. S. E. F. F., GOYACHE, J. O. A. Q. U. Í. N., and SUÁREZ, G. U. I. L. L. E. R. M. O. (1988). Behavior of aflatoxin during the manufacture, ripening and storage of Manchego-type cheese. Journal of Food Science, 53(5), 1373-1388. https://doi.org/10.1111/j.1365-2621.1988.tb09280.x.

[24] Van Brandt, L., Coudijzer, K., Herman, L., Michiels, C., Hendrickx, M., and Vlaemynck, G. (2011). Survival of Mycobacterium avium ssp. paratuberculosis in yoghurt and in commercial fermented milk products containing probiotic cultures. Journal of Applied Microbiology, 110(5), 1252-1261. https://doi.org/10.1111/j.1365-2672.2011.04979.

[25] Clark, S., Costello, M., Drake, M. A., and Bodyfelt, F. (2009). The sensory evaluation of dairy products. In The Sensory Evaluation of Dairy Products. https://doi.org/10.1007/978-0-387-77408-4.

[26] Melo, J., Andrew, P. W., and Faleiro, M. L. (2015). Listeria monocytogenes in cheese and the dairy environment remains a food safety challenge: The role of stress responses. Food Research International, 67, 75-90.

[27] Oliver, S. P., Jayarao, B. M., and Almeida, R. A. (2005). Foodborne pathogens in milk and the dairy farm environment: Food safety and public health implications. Foodbourne Pathogens & Disease, 2(2), 115-29.

[28] Garcell, H. G., Garcia, E. G., Pueyo, P. V., Martín, I. R., Arias, A. V., and Serrano, R. N. A. (2016). Outbreaks of brucellosis related to the consumption of unpasteurized camel milk. Journal of Infection and Public Health, 9(4), 523-527.

[29] Johler, S., Weder, D., Bridy, C., Huguenin, M. C., Robert, L., et al. (2015). Outbreak of staphylococcal food poisoning among children and staff at a Swiss boarding school due to soft cheese made from raw milk. Journal of Dairy Science, 98(5), 2944-2948.

[30] Gould, L. H., Mungai, E., and Barton Behravesh, C. (2014). Outbreaks attributed to Cheese: Differences between outbreaks caused by unpasteurized and pasteurized dairy products, United States, 1998e2011. Foodborne Pathogens and Disease, 11(7), 545-551.

[31] Motarjemi, Y., Moy, G. G., Jooste, P. J., and Anelich, L. E. (2014). Milk and dairy products. In Y. Motarjemi, & H. Lelieveld (Eds.), Food safety management—a practical guide for the food industry (pp. 83-117).

[32] Lindström, M., Myllykoski, J., Sivelä, S., and Korkeala, H. (2010). Clostridium botulinum in cattle and dairy products. Critical Reviews in Food Science and Nutrition, 50(4), 281-304.

[33] Heuvelink, A. E., van Heerwaarden, C., Zwartkruis-Nahuis, A., Tilburg, J. J., Bos, M. H., Heilmann, F. G., et al. (2009). Two outbreaks of campylobacteriosis associated with the consumption of raw cows' milk. International Journal of Food Microbiology, 134(1e2), 70-74.

[34] Honish, L., Predy, G., Hislop, N., Chui, L., Kowalewska-Grochowska, K., Trottier, L., et al. (2005). An outbreak of E. coli O157:H7 Hemorrhagic colitis associated with unpasteurized Gouda cheese. Canadian Journal of Public Health/Revue Cana-

dienne De Sante'e Publique, 96(3), 182-184. Retrieved from: http://www.jstor.org/stable/41994536.

[35] Claeys, W. L., Cardoen, S., Daube, G., De Block, J., Dewettinck, K., Dierick, K., et al. (2013). Raw or heated cow milk consumption: Review of risks and benefits. Food Control, 31(1), 251-262.

[36] Centers for Disease Control and Prevention (CDC). (2015). Multistate outbreak of listeriosis linked to Blue Bell creameries products (final update). Atlanta, GA: Centers for Disease Control and Prevention. http://www.cdc.gov/listeria/outbreaks/ice-cream-03-15.

[37] Fetsch, A., Contzen, M., Hartelt, K., Kleiser, A., Maassen, S., Rau, J., et al. (2014). Staphylococcus aureus food-poisoning outbreak associated with the consumption of ice-cream. International Journal of Food Microbiology, 187, 1-6.

[38] Pouillot, R., Klontz, K. C., Chen, Y., Burall, L. S., Macarisin, D., et al. (2016). Infectious dose of Listeria monocytogenes in outbreak linked to ice cream, United States, 2015. Emerging Infectious Diseases, 22(12), 2113.

[39] El-Sharef, N., Ghenghesh, K. S., Abognah, Y. S., Gnan, S. O., and Rahouma, A. (2006). Bacteriological Quality of ice cream in Tripoli—Libya. Food Control, 17(8), 637-641. https://doi.org/10.1016/j.foodcont.2005.04.001.

[40] Goff, H. D. and Hartel, R. W. (2013). Ice Cream. 7th Edn. Springer: New York.

[41] Pearman, P. (2015). The Ice Cream Compositional Requirements laid down by the Ice Cream Alliance. Available from: http://www.ice-cream.org.

[42] CFR - Code of Federal Regulations. Food for Human Consumption. Title 21, volume 2 part 131 [21CFR131.200]. Office Federal Register, Washington, D.C.

[43] CFR - Code of Federal Regulations. Food for Human Consumption. Title 21, volume 2 part 131 [21CFR131.203]. Office Federal Register, Washington, D.C.

[44] CFR - Code of Federal Regulations. Food for Human Consumption. Title 21, volume 2 part 131 [21CFR131.206]. Office Federal Register, Washington, D.C.

[45] CFR - Code of Federal Regulations. Food for Human Consumption. Title 21, volume 2 part 131 [21CFR131.111]. Office Federal Register, Washington, D.C.

[46] CFR - Code of Federal Regulations. Food for Human Consumption. Title 21, volume 2 part 131 [21CFR131.112]. Office Federal Register, Washington, D.C.

[47] CODEX STAN 243-2003. Codex Standard for Fermented Milk. Revised 2010.