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Microbial Quality Assessment of Ice Cream Sold in Umuahia, South-Eastern Nigeria: A Comparative Study

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Abstract
Microbial analysis was conducted on seventeen ice cream samples; industrially produced (X_1-X_7), locally produced (Y_1-Y_6) and fast food ice cream (Z_1-Z_4) purchased within Umuahia respectively. The total aerobic plate count (TAPC) and the total fungal count (TFC) ranged from 4.05×10^4 (Z_4) to 1.83×10^5 (Y_3) cfu/g (TAPC); and 1.00×10^3 (Y_4) to 3.00×10^3 (X_2, X_7, Y_1, Y_2, Y_3, Y_5, Y_6) cfu/g (TFC). The total coliform count (TCC), the total Staphylococcal (TSC) and *Salmonella* counts (SAC) ranged from 8.00×10^3 (X_3), to 3.80×10^4 (Y_6) cfu/g (TCC); 3.00×10^3 cfu/g (X_2), to 1.50×10^4 (Y_2) cfu/g (TSC); and 2.00×10^3 (X_7), to 1.30×10^4 (Y_1) cfu/g (SAC); with a zero count for the fast food samples. *Escherichia coli* (EC) and *Shigella* counts (SHC) ranged from 4.00×10^3 (Y_2), to 1.20×10^4 (Y_6) cfu/g (EC) and 4.00×10^3 (Y_3), to 6.00×10^3 (Y_2) cfu/g (SHC); with a zero count for both the industrially produced and fast food samples. The *Lactobacillus* count ranged from 3.65×10^4 (X_5) to 9.35×10^4 (X_4) cfu/g. The distribution of the isolates include: *Staphylococcus aureus* 7 (41.18%), *Lactobacillus* spp. 17 (100%), *Bacillus* spp. 13 (76.47%), *Shigella* spp. 2 (11.76%), *Salmonella* spp. 3 (17.65%), *Escherichia coli* 4 (23.53%), *Streptococcus* spp. 9 (52.94%), *Aspergillus* spp. 1(5.88%) and *Fusarium* spp. 16 (94.12%). Statistical analysis showed a significant difference between the ice cream sample categories ($P<0.05$; $P<0.01$). Comparing the general counts, the study concluded that the microbial quality of ice cream sold in fast food joints in Umuahia was better than the other two categories. The presence of food-borne pathogens beyond the acceptable limit is of public health importance.
Keywords: microbial quality, ice cream, Umuahia, comparative study.

1.0 Introduction

Ice cream is a popular product consumed particularly in summer as well as throughout all year and continues to be a dominant interest of large segments of the population (Mann, 1988). Ice cream contains mainly milk fat (about 10-16%, depending on the standard), non-fat milk solids (about 9-12%), sugar (sucrose) (9-12%), water (55-64%) and 0.20-0.50% stabilizer and/or emulsifier (Pick *et al*., 1990; Potter and Hotchkiss, 1995; Silliker *et al*., 1980). Fruits, nuts, candies and syrups are optionally added into ice cream for flavor enrichment. Any of these may contribute microorganisms and affect the quality of the product as judged by the bacterial load or its content of various species of bacteria (Frazier and Westhoff, 1992). It is sold in packages or in open containers at retail outlets/ ice cream parlours, the open variety being distributed manually in scoops, cones or sundaes across the counter (Çadlayanlar *et al*., 2009; Champagne *et al*., 1994; Farrag and Marth, 1992; Marshall and Arbuckle, 1996; Warke *et al*., 2000).

Microorganisms are transmissible to humans through milk and milk products (Tomislav *et al*., 2012; Vasvada, 1988). As a milk based product, it is a good media for microbial growth due to its high nutrient value, almost neutral pH value (pH 6-7) and long storage duration. The presence of pathogens in ice cream samples is mostly by means of tools and equipment, water, workers, environment, packaging materials and contaminations during the transportation and distribution of ice cream (Elliot *et al*., 1982). Ice cream can also get contaminated with microorganisms if some ingredients have been added after pasteurization (Jay, 1992). Some of the diseases associated with pathogenic bacteria, associated with the dairy industry are tuberculosis, brucellosis, diphtheria, Scarlet fever, Q-fever and most commonly gastroenteritis (Miettinen *et al*., 1999; Vasvada, 1988).

According to the World Health Organization (1988), national surveillance of milk and milk products conducted around the world has revealed that generally 5% of ice cream produced is contaminated. The processing pasteurization temperatures that are currently used are sufficient to destroy the most heat-resistant of the non-spore forming pathogenic organisms such as *Mycobacterium tuberculosis* and *Coxiella burnetti* (Adams and Moss, 1995). The microorganisms that can stand pasteurization are mainly the gram positive spore-forming bacteria and thermoduric non-spore formers. The rest of gram negative and gram positive non-spore forming bacteria, yeasts and moulds are destroyed by pasteurization (Jay, 1996). The microflora of these frozen products before pasteurization is determined by ingredients used in making the products (Roberts *et al*., 1998).These usually include *Micrococcus* species, *Bacillus subtilis* and *Lactobacillus casei* that can withstand pasteurization (Roberts *et al*., 1998; Silliker *et al*., 1980).

Under modern production conditions, thermoduric psychrotrophic microorganisms and particularly *Bacillus* species determine the shelf life of pasteurized milk products during extended storage (Frank *et al*., 1993; Garcia-Armesto and Sutherland, 1996).The improved pre-packaging treatment has therefore reduced the microbiological

load in dairy products. The microbial count usually goes down to below 80 per ml after the ice cream mix has gone through proper or adequate pasteurization which is usually more severe than the minimal requirements and this is mainly as a result of the spores that survive the heat treatment (Roberts *et al.,* 1998).Yeasts and moulds isolated from ice cream have been mainly associated with the use of cane sugar obtained from inadequately treated raw sugar cane (Roberts *et al*., 1998; Silliker *et al*., 1980).

Buckner *et al*. (1993) stated that microorganisms cannot grow in frozen mixes and it is only when there is delay between pasteurization and freezing that spoilage by microorganisms can occur. The microbiological quality of ice cream during retail marketing mainly depends upon the post production handling of the product as well as efficiency and sanitary conditions during frozen storage (Nelapati *et al*., 2009; Warke *et al.*, 2000). The machines used to serve soft ice cream if not properly maintained can be the major sources of contamination due to biofilm formation (Dempsey *et al*., 2000; Hennessy *et al*., 1996; Hilderbrandth, 2000; Kleer and Nelapati *et al.*, 2009).

Outbreaks of *Salmonella* have been reported in ice cream and other frozen desserts in different parts of the world such as USA, UK and India (Dodhia *et al*., 1998; Hennessy *et al*., 1996; Indar-Harrinauth *et al*., 2001; Mahon *et al*., 1999). Nation-wide outbreak of Salmonellosis was more likely the result of contamination of pasteurized ice cream premix during transport in tanker trailers that had previously carried non-pasteurized liquid eggs containing *Salmonella enteritidis* (Hennessy *et al*., 1996). Pathogens if present may survive in ice cream for many months (Okojoh, 2006; Roberts *et al*., 1998).

Several factors are important in the production of high quality ice cream and are associated with the stages of production (Little and Delouvois, 1999; Roberts *et al*., 1998). These include cleaning and disinfection, hygiene of storage area, hygienic design and personnel training, and failure to adhere to these practices may lead to high bacteria counts and potential public health problems (Roberts *et al*., 1998). Microorganisms have been found to contaminate ice cream mix and proliferate as a result of temperature abuse; leading to food poisoning (Buckner, 1993; Silliker *et al*., 1980; Tomislav *et al*., 2012; Warke *et al*., 2000). Food poisoning events have been reported from inefficient frozen storage chain under warm tropical climatic conditions leading to temperature abuse during transporting and distribution of ice cream (Champagne *et al*., 1994; Warke *et al*., 2000). This is because under such conditions the psychrotrophic bacteria present in the ice cream are activated (Tomislav *et al*., 2012). As most of the ice cream consumers are children of the vulnerable age groups, it is required to be microbiologically safe (Warke *et al*., 2000), hence the necessity of this study. Therefore, this study is aimed at assessing the microbial quality of ice cream offered for public consumption in Umuahia and its potential to pose risk to public health, and to compare the microbial quality between industrially produced, locally produced ice cream and ice cream sold in fast food joints in Umuahia, Abia state.

2.0 Materials and methods

2.1 Sample collection

A total of 17 ice cream samples, 7 samples of industrially produced (Fan milk, Vanilla flavor), 6 locally produced and 4 fast food ice cream (Banana, Strawberry and Vanilla flavors) samples were purchased from street vendors, fast food joints and hawkers within Umuahia metropolis respectively; producers and stores were chosen randomly. The samples were collected and transported to the laboratory in an ice-box within an hour of collection and were preserved in the refrigerator at 4-5 C prior to the commencement of the analysis. The samples were properly labelled and were analyzed within 2 hours of collection.

2.2 Experimental design

The three categories of ice cream analyzed were denoted using different representations:

X= industrially produced ice cream samples ($X_1 – X_7$) (Fan milk, Vanilla flavor).

Y= locally produced ice cream samples (Y_1-Y_6)

Z= Fast food ice cream samples (Z_1-Z_4); Z_1 and Z_2 (Vanilla flavor), Z_3 (Banana flavor), and Z_4 (Strawberry flavor).

2.3 Sample dilution, Isolation, enumeration and identification of microorganisms

2.3.1 Media used and their preparation

Nutrient agar (Titan Biotech Ltd. Rajasthan, India), MacConkey agar (Titan Biotech Ltd. Rajasthan, India), Eosin methylene blue agar (Titan Biotech Ltd. Rajasthan, India), Sabouraud dextrose agar (Titan Biotech Ltd. Rajasthan, India), *Salmonella-Shigella* agar (Titan Biotech Ltd. Rajasthan, India), Mannitol salt agar (Titan Biotech Ltd. Rajasthan, India), De Man Rogosa and Sharpe agar (Guandong Huankai Microbial Sci. and tech. Co. Ltd., Guanzhou), Simmon's citrate agar (Titan Biotech Ltd. Rajasthan, India), Peptone water (Titan Biotech Ltd. Rajasthan, India), and Methyl Red-Voges Proskauer (MR-VP) Broth (Titan Biotech Ltd. Rajasthan, India) were used. The media were prepared according to the manufacturers' instructions and were brought to boiling before sterilization (except for *Salmonella-Shigella* agar) at 121 C for 15 minutes at 15psi.

2.3.2 Serial dilution

A representative quantity (25 grams) of each of the ice cream samples was aseptically homogenized in 225mls of sterile normal saline in sterile beakers, after which 1 ml of each ice cream sample was aseptically transferred into sterile test tubes containing 9mls each of normal saline to give a dilution of 1/10 using sterile pipettes. From this dilution, a serial dilution of up to 10^{-4} was carried out.

2.3.3 Isolation and enumeration

The spread plate method was used. From each of the sample dilutions, 0.1ml aliquot was aseptically transferred onto the surface of freshly prepared solidified Nutrient agar, MacConkey agar, Sabouraud dextrose agar, Mannitol salt agar, De Man Rogosa and Sharpe agar and Eosin methylene blue agar in sterile Petri dishes in duplicates using sterile pipettes and was spread evenly over the surface with the aid of a sterile glass spreader. The plates were inverted and were incubated at 35±2 C for 24-48 hours and at 25 C for 72-120 hours for yeast and mould count. The developed colonies were counted using a colony counter and the results were recorded; plates containing 30-300 colonies were selected. Average of duplicate plates were counted and recorded as the number of colony forming units (cfu/g) of each ice cream sample. The plate counts per gram were recorded using: $\frac{N}{V \times D}$

Where N= Number of colonies; V= Volume of the inoculums; D= Dilution factor.

Pure cultures of the isolates were obtained by sub-culturing in fresh medium using the streak plate method. The final cultures containing discrete colonies were transferred onto McCartney bottles containing agar slants and were stored in the refrigerator at 4 C for further studies.

2.3.4 Identification of the isolates

Bacterial isolates were identified based on standard microbiological, cultural, morphological and biochemical characteristics as described by Cheesbrough (2006) and Harley and Prescott (1996), while the fungal isolates were identified using standard taxonomic schemes as described by Alfred (2006) and David *et al*. (2007).

2.4 Statistical analysis

One-way ANOVA was used to compare the total aerobic plate count data between the three categories of ice cream. Total aerobic plate counts were transformed using Logarithm to the base 10 (Log_{10}) before the statistical treatment. Significant differences between the mean values were then compared using the least significant difference (LSD) Procedure as described by Visweswara (2009).

3.0 Results and discussion

The microbial quality of ice cream offered for public consumption in Umuahia was investigated in this study and different microorganisms were isolated; *Lactobacillus* spp., *Streptococcus* spp., *Staphylococcus aureus*, *Bacillus* spp., *Salmonella* spp., *Shigella* spp., *Escherichia coli*, *Aspergillus* spp. and *Fusarium* spp. All the 17 samples of ice cream examined showed positive for one type of bacteria and mold or the other. For the industrially produced variety, Fan milk (Vanilla flavor) was the only brand analyzed as this is the most popular brand of choice for most individuals within the study area, while for the fast food variety, 3 flavors (Strawberry, Vanilla, and Banana) were analyzed.

From the results obtained, the total aerobic plate count of all the ice cream samples apart from the locally produced samples fell within the acceptable limit of 10^5 (Table 1). Bacterial load not more than 10^5 bacteria in ice cream samples reflect good hygiene (Frazier and Westhoff, 1978), however values at or above the 'M' value (10^5) are unacceptable (Frazier and Westhoff, 2014). Though higher counts were recorded in the industrially produced samples as was indicated by the mean count of 7.16×10^4 cfu/g, the highest counts were recorded in the locally produced ice cream samples (Table 1) as was indicated by a mean count of 1.45×10^5 cfu/g. The results of the total aerobic plate count obtained in this study apart from the locally produced variety were similar to that obtained by Okojoh (2006) and Moshood and Tengku (2013) as all fell within the acceptable limits.

Of the three categories of ice cream analyzed, the percentage occurrence of the bacterial isolates was higher in the locally produced ice cream samples and the least incidence was recorded in the fast food variety (Table 4). The difference may have been brought about by the different conditions under which each of the food products was stored and distributed or served (Ahmed *et al*., 2009; Aleksieva and Mirkow, 1983; Little and De louvis 1999; Wilson *et al*., 1997; Wouafo *et al*., 1998;). The microbial counts of the locally produced ice cream were higher when compared to the other two categories. This may have originated from the initial micro flora of raw milk and other ingredients and their quality, insufficient/no heat treatment, the production environment and poor personal hygiene (Yaman *et al*., 2006). It has been previously stated that production of ice cream locally on a small scale rather than industrially is also a major factor associated with contamination of ice cream (Kanbakan *et al*., 2004). However, microbial counts of the industrially produced samples were a little bit higher than that sold in fast food joints (Table 2). The counts could have resulted from the inadequate processing of the ice cream mix or from the frequent freezing and thawing of the ice cream (due to the fact that not all the ice cream will

remain frozen until after sales, and those remaining from sales are sent back to the freezer to be re-sold the next day in order to maximize profit).

For the bacterial isolates, *Lactobacillus* spp. had the highest incidence and percentage occurrence (100%) as it occurred in all the samples, while *Shigella* spp. had the lowest incidence with a percentage occurrence of 11.76% (Table 4). The highest (9.35×10^4 cfu/g) and the least *Lactobacillus* counts (3.65×10^4 cfu/g) were recorded in the industrially produced samples. *Lactobacillus* is indispensable to the food and dairy industry. They are usually not pathogenic (Willey *et al*., 2008). *Lactobacillus,* a member of the lactic acid bacteria constitutes a member of the probiotic bacteria. It has been established that according to the Environmental Illness Resource, the benefits that *Lactobacillus* can provide include: preventing and treating diarrhoea caused by antibiotics; preventing of vaginal and urinary-tract infections; preventing of overgrowth of bacteria like *Helicobacter pyroli*, *Salmonella* and *E.coli*, and helping with the digestion of lactose products (Frazier and Westhoff, 2014). Lactobacilli are also part of the normal flora of the human body in the mouth, intestinal tract and vagina. They are sometimes responsible for the spoilage of beer, milk and meat because their metabolic products contribute undesirable flavors and odors (Willey *et al*., 2008).

Bacillus spp. was detected in 13 out of the 17 samples and had a percentage occurrence of 76.47%. *Bacillus* species and other thermoduric bacteria are spore-formers and can become part of some of the ingredients of the ice cream mix, and thus can persist after pasteurization (Matthews *et al*., 2013). *Bacillus* species are common environmental contaminants and has been shown to be a transient microflora of the hand and surfaces due to its spore forming ability (Oranusi *et al*., 2013). *Bacillus* species have been implicated in human pathogenesis and as food spoilage organisms (Collins and Lyne, 2013).

Streptococcus spp. was detected in 9 out of the 17 samples with a percentage occurrence of 52.94%. Though *Streptococcus* spp. acts a probiotic; the only probiotic in the *Streptococcus* group is *Streptococcus thermophilus* (Frazier and Westhoff, 2014).The isolation indicates favourable environment within the ice cream capable of promoting the growth of these organisms. The presence of these organisms is of health significance as some of them may be capable of causing various ailments of man which can be fatal (Okojoh, 2006).

Regarding to *Staphylococcus aureus*, 7 samples yielded positive with an incidence rate of 41.18%. The maximum occurrence was recorded in the locally produced ice cream samples (1.50×10^4 cfu/g) while the least incidence and a mean count of 2.00×10^3 cfu/g was recorded in the industrially produced samples; none was detected in the fast food variety (Table 4 and Table 5). The absence of *S. aureus* has been rarely reported in several studies (Maifreni *et al*., 1993; Wilson *et al*., 1997). The presence of *S. aureus* may have resulted from either insufficient pasteurization of milk, or human exposure (Yaman *et al*., 2006). In humans, the main reservoir of *S. aureus* is the nasal cavity. The organism finds their way to the skin and into wounds directly or indirectly. The most common skin sources are arms, hands and face. In addition to skin and nasal cavities, *S. aureus* may be found in the eyes, throat and intestinal tract (Yaman *et al*., 2006). From these sources, the organism finds its way into air and dust, onto clothing, and in other places, from where it may contaminate foods (Jay, 1996).There are other sources like coughing, talking and sneezing which produce droplets. These droplets could settle on ice cream during transportation, storage and retailing (Okojoh, 2006). *S. aureus* which is mainly transmitted from man and animals can lead to Staphylococcal food poisoning as a result of growth of the organism and release of enterotoxin in the food.

Approximately 59% of the samples contained coliforms (Table 4). 57.1% of the industrially produced samples (4 out of 7 samples) had coliforms of which the count ranged from 8.00×10^3 to 1.50×10^4 cfu/g, with a mean count of 1.05×10^4 (cfu/g); while that of that of the locally produced samples (which all showed positive for coliforms) ranged from 1.00×10^4 to 3.80×10^4 cfu/g with a mean count of 2.37×10^4cfu/g. No coliforms were detected in the fast-food variety (Tables 2, 4, and 5). Coliforms being non-spore formers should be susceptible to pasteurization. Their post pasteurization presence in ice cream may be due to faulty heat process or to post pasteurization contamination by handlers with poor sanitary practices. The level of presence of these organisms in food has been described as an index of food hygiene (Frazier and Westhoff, 1978; Jay, 1978). A study conducted by Ahmed and Shakoori (2002) reported 640-683 colonies/100ml of drinking water. The ice cream manufacturers used the same water for the preparation of ice cream as well as for washing of their hands and utensils. Once the ice cream become contaminated, freezing temperatures later could not make the product safe (Jay, 1996), and ice cream produced in domestic or catering premises may be relatively important vehicles for the cause of gastrointestinal diseases (Yaman *et al*., 2006).

Further, *E.coli* was detected in four samples (all of which were the locally produced variety) with an incidence rete of 23.50%. None was detected in the industrially produced and fast food samples (Tables 4 and 5). The *E.coli* count ranged from 4.00×10^3 to 1.20×10^4 cfu/g with a mean count of 7.75×10^3 cfu/g; *E.coli* is an indicator of faecal contamination and the possibility of the presence of enteric pathogens. Its presence is mostly associated with poor water quality.

Other species of bacteria isolated as earlier indicated are *Salmonella* spp. and *Shigella* spp. 17.65% of the samples were found to be positive for the presence of *Salmonella* spp. *Salmonella* spp. had a count ranging from

2.00×10^3 cfu/g in the industrially produced variety to 1.30×10^4 cfu/g in the locally produced ice cream samples with a mean count of 9.00×10^3 cfu/g. *Salmonella* spp. was detected in only one of the industrially produced ice cream samples and none was recorded in the fast food variety. *Salmonella* is still the most important acute agent causing food borne diseases (Tood, 1997). The presence of *Salmonella* in ice cream may be due to either eggs or egg powder used in the ice cream production as being stated in previous works (Yaman *et al*., 2006). Barret (1986) stated that the presence of *Salmonella* in ice cream could be due to the use of contaminated milk for the preparation; another reason could be the unhygienic handling and use of contaminated ingredients for the preparation of the products. The presence of *Salmonella spp.* may pose a great risk for public health since *Salmonella* outbreaks from ice cream have been reported previously (Hennessy *et al*., 1996; Matsuo *et al*., 1995; Vought and Tatini, 1998). However, *Shigella* spp. was only detected in 2 (11.80%) samples which were the locally produced variety (Tables 4 and Table 5) with a mean count of 5.00×10^3 cfu/g. *Shigellae* are mainly transmitted by "food, fingers, faeces and flies" from person to person. They are highly communicable; the infective dose is in the order of 10^3 organisms (Geo *et al*., 2013). Shigellosis caused primarily by *S. sonnei* has become an important problem in day-care centers in the United States; *S. dysenteriae* can spread widely (Geo *et al*., 2013). The presence of *Shigella* may be due to the soiled hands of the persons handling the product.

The results of the fungal counts were similar for the three categories (Table 3) as was indicated by their mean counts which ranged from 2.00×10^3 to 2.66×10^3 cfu/g. The least fungal count was recorded in the fast food variety as was indicated by their mean count (2.00×10^3 cfu/g), followed by the industrially produced samples (2.29×10^3 cfu/g); the locally produced variety had a mean count of 2.67×10^3 cfu/g. (Fungal counts ranged from 1.00×10^3 to 3.00×10^3 cfu/g) (Table 3). The result suggests the need for the control of adequate heat treatment of ice cream and appropriate storage conditions in catering premises. Of all the ice cream samples analyzed, *Fusarium* spp. was detected in 16 out of the 17 samples (94.1%) while *Aspergillus* spp. was detected in only one (5.9%) of the samples. It should be noted that some species of *Aspergillus* are known to produce mycotoxins which are harmful to man, thus, their presence in ice cream is undesirable (Okojoh, 2006). *Fusarium* is also reported to produce mycotoxins which are also responsible for the contamination of food and feed (Pelczar *et al*., 1993); as they have been implicated in superficial, cutaneous, sub-cutaneous and systemic mycoses (Oranusi and Olarewaju, 2013), their presence in foods may pose a great risk for public health. The presence of these organisms in significant numbers indicates contamination from handlers during processing, and the microbial load could be attributed to the rate of exposure during sale (Jay, 1992).

Generally, the level of contamination for the fast food ice cream was lower when compared to the other two categories. This may be as a result of some of the organisms not surviving freezing temperatures for extended periods or being injured at these storage temperatures (Adams and Moss, 1995; Nelapati *et al*., 2009) or as a result of an improvement in the hygiene employed during the preparation and handling of the ice cream mix.

Finally, the results from the statistical analysis carried out showed a significant difference between the mean total aerobic plate count data of the 3 categories of the ice cream ($P<0.05$; $P<0.01$); LSD at both 95 and 99% probability levels showed significant differences between all combinations of groups, inferring that the total aerobic plate count data between the three categories of ice cream were significantly different from each other. This implies that the microbial quality between the 3 categories of ice cream, based on total aerobic plate count data is different. The results of this study therefore reveals a need for implementing regulatory measures like good manufacturing practices, hygienic distribution and retail storage practices for ensuring microbiological safety of ice cream offered for public consumption.

4.0 Conclusion

In conclusion, although milk is sterile as it leaves the udder of a healthy cow, it can be contaminated during handling in the farm by a variety of organisms. Ice cream being a favorite food to many Nigerians and a delicacy rich in glucose, protein and fat, can be a source of infection if not properly pasteurized and handled. Even though in this study, the results of both the total aerobic plate count and the total fungal count in all the categories (apart from the locally produced variety) of ice cream fell within the acceptable limits, the isolation of *E.coli*, *Salmonella* spp., and *Shigella* spp. suggest that ice cream could be a source of infection to humans particularly for children and vulnerable elderly people by members of the Enterobacteriaceae.

The study also revealed, that in comparison in terms of overall microbial quality with both the industrially produced ice cream, the locally produced ice cream and that sold in fast food joints, the locally produced variety was poorer while that sold in fast food joints showed very little contamination. It is also clear from this study, that there is a necessity for developing the hygienic status of locally produced ice cream in domestic or catering premises, thus good hygiene practices should improve the hygienic quality of ice cream in all steps, post pasteurization and at retail level. Fast food ice cream is safe to eat and the best as far as results from this research work has shown, but further studies on the commodity should be done.

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Table 1: Total aerobic plate count of the ice cream samples

X	Bacterial count (cfu/g)	Y	Bacterial count (cfu/g)	Z	Bacterial count (cfu/g)
(X_1)	5.20×10^4	(Y_1)	1.65×10^5	(Z_1)	4.65×10^4
(X_2)	8.15×10^4	(Y_2)	1.63×10^5	(Z_2)	5.10×10^4
(X_3)	7.75×10^4	(Y_3)	1.83×10^5	(Z_3)	5.25×10^4
(X_4)	4.15×10^4	(Y_4)	5.90×10^4	(Z_4)	4.05×10^4
(X_5)	8.20×10^4	(Y_5)	1.61×10^5	-	-
(X_6)	7.90×10^4	(Y_6)	1.37×10^5	-	-
(X_7)	8.80×10^4	-	-	-	-
Mean count	7.16×10^4	Mean count	1.45×10^5	Mean count	4.76×10^4

Key: X= industrially produced ice cream; Y= locally produced ice cream; Z= fast food ice cream

Table 2: Bacterial count of the ice cream samples

Ice cream samples	TSC (cfu/g)	LC (cfu/g)	ECC (cfu/g)	SAC (cfu/g)	SHC (cfu/g)	TCC (cfu/g)
(X_1)	5.00×10^3	4.10×10^4	-	-	-	1.50×10^4
(X_2)	3.00×10^3	5.25×10^4	-	-	-	9.00×10^3
(X_3)	5.00×10^3	8.05×10^4	-	-	-	8.00×10^3
(X_4)	-	9.35×10^4	-	-	-	-
(X_5)	-	3.65×10^4	-	-	-	-
(X_6)	-	4.00×10^4	-	-	-	-
(X_7)	-	7.05×10^4	-	2.00×10^3	-	1.00×10^4
Mean count	4.33×10^3	5.92×10^4	-	2.00×10^3	-	1.05×10^4
(Y_1)	1.00×10^4	4.65×10^4	8.00×10^3	1.30×10^4	-	3.50×10^4
(Y_2)	1.50×10^4	5.15×10^4	4.00×10^3	-	6.00×10^3	3.20×10^4
(Y_3)	8.00×10^3	7.25×10^4	-	5.00×10^3	4.00×10^3	1.50×10^4
(Y_4)	1.10×10^4	6.85×10^4	7.00×10^3	-	-	1.00×10^4
(Y_5)	-	3.90×10^4	-	-	-	1.20×10^4
(Y_6)	-	6.25×10^4	1.20×10^4	-	-	3.80×10^4
Mean count	1.10×10^4	5.68×10^4	7.75×10^3	9.00×10^3	5.00×10^3	2.37×10^4
(Z_1)	-	4.95×10^4	-	-	-	-
(Z_2)	-	6.60×10^4	-	-	-	-
(Z_3)	-	8.20×10^4	-	-	-	-
(Z_4)	-	4.10×10^4	-	-	-	-
Mean count	-	5.96×10^4	-	-	-	-

Key: TSC = total *Staphyloccocal* count; LC = *Lactobacillus* count; ECC = *E. coli* count; SAC = *Salmonella* count; SHC = *Shigella* count; TCC = total coliform count

Table 3: Total fungal count of the ice cream samples

X	Fungal count (cfu/g)	Y	Fungal count (cfu/g)	Z	Fungal count (cfu/g)
(X_1)	2.00×10^3	(Y_1)	3.00×10^3	(Z_1)	2.00×10^3
(X_2)	3.00×10^3	(Y_2)	3.00×10^3	(Z_2)	2.00×10^3
(X_3)	2.00×10^3	(Y_3)	3.00×10^3	(Z_3)	2.00×10^3
(X_4)	2.00×10^3	(Y_4)	1.00×10^3	(Z_4)	2.00×10^3
(X_5)	2.00×10^3	(Y_5)	3.00×10^3	-	-
(X_6)	2.00×10^3	(Y_6)	3.00×10^3	-	-
(X_7)	3.00×10^3	-	-	-	-
Mean count	2.29×10^3	Mean count	2.67×10^3	Mean count	2.00×10^3

Key: X= industrially produced ice cream; Y= locally produced ice cream; Z= fast food ice cream

Table 4: Ice cream samples, microorganisms isolated, total incidence and percentage occurrence of the isolates

Ice cream samples	Organisms isolated									
	Staphylococcus aureus	*Salmonella* spp.	*Escherichia coli*	*Shigella* spp.	*Lactobacillus* spp.	Coliform bacteria	*Streptococcus* spp.	*Bacillus* spp.	*Aspergillus* spp.	*Fusarium* spp.
(X_1)	+	-	-	-	+	+	-	+	-	+
(X_2)	+	-	-	-	+	+	+	+	-	+
(X_3)	+	-	-	-	+	+	-	+	-	+
(X_4)	-	-	-	-	+	-	+	+	-	+
(X_5)	-	-	-	-	+	-	-	+	-	+
(X_6)	-	-	-	-	+	-	+	+	-	+
(X_7)	-	+	-	-	+	+	+	+	-	+
(Y_1)	+	+	+	-	+	+	+	+	+	-
(Y_2)	+	-	+	+	+	+	+	-	-	+
(Y_3)	+	+	-	+	+	+	+	-	-	+
(Y_4)	+	-	+	-	+	+	-	-	-	+
(Y_5)	-	-	-	-	+	+	+	+	-	+
(Y_6)	-	-	+	-	+	+	+	-	-	+
(Z_1)	-	-	-	-	+	-	-	+	-	+
(Z_2)	-	-	-	-	+	-	-	+	-	+
(Z_3)	-	-	-	-	+	-	-	+	-	+
(Z_4)	-	-	-	-	+	-	-	+	-	+
Incidence	7	3	4	2	17	10	9	13	1	16
% Occurrence	41.18%	17.65%	23.53%	11.76%	100%	58.82%	52.94%	76.47%	5.88%	94.12%

Table 5: Incidence of microorganisms in each of the ice cream sample categories and their percentage of occurrence

Isolates	Incidence in 'X'	Percentage occurrence	Incidence in 'Y'	Percentage occurrence	Incidence in 'Z'	Percentage occurrence
Escherichia coli	-	-	4	66.67%	-	-
Salmonella spp.	1	14.29%	2	33.33%	-	-
Coliform bacteria	4	57.14%	6	100%	-	-
Lactobacillus spp.	7	100%	6	100%	4	100%
Shigella spp.	-	-	2	33.33%	-	-
Bacillus spp.	7	100%	2	33.33%	4	100%
Streptococcus spp.	4	57.14%	5	83.33%	-	-
Staphylococcus aureus	3	42.86%	4	66.67%	-	-
Aspergillus spp.	-	-	1	16.67%	-	-
Fusarium spp.	7	100%	5	83.33%	4	100%

Key: X= industrially produced ice cream; Y= locally produced ice cream; Z= fast food ice cream