Original Research Article

Prevalence of *common* microbiological pathogencontamination in processed milk and milk products in Nairobi County

Abstract

Milk has an outstanding nutritional quality but it is also an excellent medium for bacterial growth and an important source of bacterial infection when consumed without pasteurization. This study aimed at establishing the prevalence of *Total Viable Count, Escherichia coli, Staphylococcus aureus* and *Listeria monocytogenes* contamination on processed milk and milk products. The study was carried out in Karen, Kibera and Langata Sub- Counties of Nairobi County which were purposively chosen because they have glaring contrasts in living standards. Samples of fresh milk, yoghurt cheese and ice creams were collected from supermarkets and prepared for analysis of microorganisms. All isolates were characterized and identified based on their morphological and cultural characteristics. The total viable count (TVC) were detected in 100% of the samples collected and there was significant statistical variation ($P \leq 0.05$) in the contamination level among the products. Of the samples collected in Karen, Ice cream had the highest contamination level (3.26 $\log_{10}$CFU ml $^{-1}$). Ice cream samples from Langata had the highest TVC contamination levels at 4.35 $\log_{10}$ CFU ml $^{-1}$. The overall prevalence of *E. coli* in milk and milk products was 41.6% with a mean count of 0.34 $\log_{10}$ CFU ml $^{-1}$ in Karen, 0.07 $\log_{10}$ CFU ml $^{-1}$ in Kibera and 0.11 $\log_{10}$ CFU ml $^{-1}$ in Langata while *Staphylococcus aureus* was detected in 33.3% of the milk and milk products. The occurrence and detection of *E. coli* and *S. aureus* foodborne pathogens in milk and milk products represent a health risk to consumers.

Therefore, there is need to improve the microbial quality of milk and milk products by employing measures that will establish proper management practices to ensure improved hygiene, good manufacturing practices and food systems that will help to minimize microbial contamination.

Key words: Pathogens, *Total viable count, Escherichia coli, Enterobacteriaceae, Staphylococcus aureus,Listeria monocytogenes*

1.0 Introduction

The demand for milk and milk products in Kenya is among the highest in the East African region and in the developing nations. According to FAO (2011), the annual per capita consumption of milk and dairy products is estimated at 19 kg in rural areas and 125 kg in urban areas. Milk is a healthy food product for humans, and it is obtained from a variety of animal sources, such as cows, goats, sheep, and buffaloes. Animal milk is processed into commercial products such as powdered, skimmed, condensed milk, yogurt and cheese or traditional products fermented milk and *warankasi* (cheese) and *nono* (Jans *et al*., 2017). In Kenya, a significant portion of milk is consumed locally with only a small fraction marketed commercially. This is because of inadequate infrastructure and skilled personnel required to commercially process milk. However, the safety of milk and milk products may be compromised by the presence of harmful microorganisms such as pathogenic bacteria and yeasts, parasites, and viruses (Azad & Ahmed, 2016)

A wide variety of dairy products such as butter, cheese, ice cream, yoghurt, paneer, etc. are manufactured mainly from the cow milk and also from the milk of other dairy animals such as buffaloes, goats, sheep and camels. The unique composition of moisture and with an excellent

richness of numerous nutrient that providefavorable environment for the growth and proliferation of microorganisms such as bacteria and fungi some of which are pathogenic to both human and animals. Milk-borne pathogenic bacteria constitute about 90% of all the dairy animals' related diseases (Ryser, 1998). The main microbiological hazards associated with consumption of raw milk include*Staphylococcus aureus, Salmonella* spp., *Listeria monocytogenes, Escherichia coli* O157:H7 and *Campylobacter*.If milk and milk products are not prepared under strict hygienic and sanitary conditions, these microbes may gain access through different ways and cause spoilage resulting into economic loss to the dairy industry (Berhe *et al*., 2020). Again, it has been observed that if hygienic practices during milking, handling and storage of milk were substandard, the resulting milk products would be poor in quality (Merhawit*et al*. 2014). In many populations, milk processing is largely a household process and is characterized by poor hygiene practices such as inadequate washing of hands, improper use of sterilization equipment (Bereda *et al*., 2013; Akinyemi *et al*., 2020). Some of the pathogens such as *Listeria monocytogenes*, *Salmonella* species, *Staphylococcus aureus*, have been implicated as food poisoning agents (Pal, 2013). Depending on the concentration of these contaminants consumers of these products become exposed to disease such as listeriosis, shigellosis, hepatitis, compromised gut integrity etc.

It is difficult to estimate the incidence of foodborne infection by these contaminants because little is known about the magnitude of microbiological hazards associated with quality of raw bulk milk, especially with regard to contamination and the prevalence of foodborne pathogens. In 2005 close to 1.8 million children died because of diarrheal diseases because they are the most susceptible and are easily exposed due to their high consumption of dairy products either as cow's milk and related by-products in their diet. The microbiological safety is very important

and plays a significant role in the quality control of milk and dairy products. This study focused establishing the prevalence of microbial contamination in fresh milk and milk products which are commonly consumed by majority of households in Kenya

2.0 Materials and methods

2.1 Study area

The study was carried out in Karen, Kibera and Langata Sub- Counties of Nairobi County. These locationspurposively chosen because they have glaring contrast in living standards ranging from plush homes of Karen and Langata and sprawling slums of Kibera characterized poor living conditions. Karen, Langata and Kibera arelocated to the South west of Nairobi. Langata is predominantly mixed development with all categories of households from most affluent in Karen to the low-income groups spread across the wards while Kibera is characterized by an ethnic diverse community with high levels of poverty, crime and lack of common basic amenities (Ochungo*et al*., 2019)

Insert figure 1

2.2 Sample Size determination for Milk products

For each assessedmilk processing company, random sampling technique was used in selecting their brands of milk and milk products at the point of sale in the 3 different study areas: Karen, Langata, and Kibera. A total of 36 samples of milk and milk products were picked from the 3 different study areas, 9 samples for each category namely, fresh milk, yoghurt, cheese and ice cream. The supermarkets or the selling points were randomly selected from Langata and Kibera sub- County in the areas where the consumers' samples were also picked.

2.3 Sampling

Samples of fresh milk, yoghurt cheese and ice cream were collected in 500ml packagesat formal points of sell in Langata, Karen and Kibra and put in a cooler box with ice packs and transported to the laboratory. The samples were submitted to the lab on the same day of collection and stored 4 °C-6°C in a refrigerator until testing. Analysis commenced immediately under the guidance of the lab in charge.

2.4 Samples preparation

Samples of fresh milk, yoghurt werevortexedin a vortexed mixture for 10 sec ensure they were homogenously mixed while the ice cream samples were prepared by first melting them in a fridge at 4°C-6°C. The melted ice cream was then blended at low speed for 1 minute to make a homogeneous mix.One ml was then pipetted and taken as the representative sample. Fifty gram of cheese samples was aseptically weighed and put into 450mL of the required diluent then blended at low speed for 2 minutes to make a homogeneous mixture after which a serial dilution was done with 50g:450ml taken as the primary dilution.

2.5 Making dilutions

A bottle with the 9mL buffered peptone was labelled with sample lab reference number. The prepared sample were then aseptically opened near a Bunsen burner flame, a sterile 1ml Pipette was attached to the micropipette and one ml of the sample was drawn. The one ml of the sample was aseptically transferred to the 9ml peptone water and then mixed by gently inverting the bottle. This formed the primary dilution (10^{-1}). Following the same procedure above serial dilutions were then made by transferring 1ml of the primary dilution (10^{-1}) into another 9ml of buffered peptone water to make the second dilution (10^{-2}), subsequent serial dilutions were done

up to the fourth dilution (10^{-4}), each time using a fresh sterile pipette.The prepared dilutions were then kept in refrigerated at 4°C-6°C.

3.0 Analytical Methods

3.1 Enumeration of Total Viable Counts

The enumeration of the total viable count was done following the KS ISO 4833-1: 2013 analysis method. Diluted samples of the fresh milk, yoghurt, cheese and ice-cream were tested and then inoculated by adding the samples into labelled sterile Petri dish.Using a sterile pipette, 1 ml of the sample of the dilutions was then aseptically transferred into sterile Petri dishes from the most dilute (10^{-4}). Approximately 15ml of Standard Plate Count Agar which had been tempered in a water bath at 47°C was aseptically added into each Petri dish containing the sample. The contents of the Petri dish were then mixed immediately by swirling gently the petri dishes repeatedly until the agar was properly mixed with the sample. This was done one plate at a time until all the samples were completed. The Petri were then left on a cool, flat surface to allow the mixture to solidify

The Memmert incubator was set at 30℃, once it attained the set temperature andthe agar poured in the petri dishes had completed solidified, the Petri dishes were then inverted and placed in the incubator undisturbed for 72 hours at 30°C. After the lapse of the 72hrs, the petri dishes were removed from the incubator and colonies in each petri dish were examined under subdued light and counted using colony counting device. The results were then recorded for each plate examined and counted as colony forming units per ml or g(cfu/ml or cfu/g)

3.2 Detection of *Escherichia coli*

The enumeration of the Escherichia coli was done following the KS ISO 7251: 2005 Horizontal method for the detection and enumeration of presumptive Escherichia coli. Samples of fresh

milk, yoghurt, cheese and ice-cream were analyzed.Sterile HiCrome chromogenic agar was added to dilutions of 10^{-2} to 10^{-4} of the samples which were pipetted on to sterile plates in duplicates, the plate was then gently rotated clockwise and anti-clockwise to mix and then left to dry. After drying, the plates were inverted and incubated at 37 °C for 24 h. The plates were then examined for evidence of growth of blue/purple colonies which were interpreted as *Escherichia coli* colonies. For the plates that had *E. coli*present, an indole test was done to further confirm the presence of *Escherichia coli*. Escherichia coli is able to break down the amino acid tryptophan into Indole and form a red ring, which is a property of *Escherichia coli* to react with Kovac's (Indole) reagent to form a red ring. The results were either indicated as absent cfu/g or present cfu/g.

3.3 Enumeration of *Staphylococcus aureus*

Enumeration of *Staphylococcus aureus* in all the samples was done as per the procedure laid down in KS ISO 6888-1: 2021 method of analysis. The diluted samples starting by the highest dilutions were then inoculated by adding each of the samples into sterile Petri dishes withBaird-Parker agar.The inoculum was then quickly and carefully spread over the surface of the agar plate using a sterile glass spreader. Care was taken not to touch the sides of the Petri dish. The plates were then left to dry at room temperatures for about 15 minutes.Once the inoculated plates had dried, they were inverted and placed in the incubator set at 38℃ for 24 hours and examined for any growth, and re-incubate for a total of 48 hours.The plates were then removed and examined for evidence of growth of black-grey shinny colonies surrounded by thin white light borders an indication characteristic of Coagulase-positive *Staphylococcus aureus*colonies on Baird Parker media. A Coagulase test was then done on the colonies as a confirmatory test for *Staphylococcus aureus*, three of the black-grey colonies observed were transferred using a sterile

loop into a sterile test tube with 0.5ml reconstituted plasma into the test tube which were then incubated at 37°C for 4hrs but observed at hourly intervals for any signs of clots formation which indicated positive results and vice versa.

3.4 Enumeration of *Listeria monocytogenes*

Enumeration of *Listeria monocytogenes* in all the samples was done as per the procedure laid down in KS ISO 11290-2: 2017 method of analysis. Twenty-five ml of the 10^{-1} dilution prepared sample was placed into 225mls of LEB (*Listeria* enrichment Broth) The solution was then uniformly mixed by slowly inverting the beaker and incubated at 30 °C for 24-26 hrs. After the lapse of the time set, 0.1ml of the pre-enriched sample above was added to 10ml of LEB (*Listeria* enrichment Broth) and incubated at 37ºC for 24hrs for selective enrichment. A streak (0.5ml) of the was then taken using a sterile loop wire and plated in a Listeria chromogenic agar, evenly distributing the inoculum throughout the surface of the plate using a sterile spreader while avoiding making contact with the plate's sides. This was then left to dry for 15minutes and incubated for 24hrs at 37ºC and a further 24 hours giving a total of 48hrs. Observation was then done for any growth of blue or blue-green colonies surrounded by an opaque cycle that would have been an indication of *Listeriaspp* growth.

3.5 Statistical analyses

Data from microbiological analyses were entered into Excel and transformed to logarithm of colony forming units per milliliter of sample ($\log_{10}$ CFU/ml) and the results were presented as means of the three replicates. All the statistical analyses were performed by of Genstat version 15 software (England) and the difference were considered significant when $P \leq 0.05$. The bacterial contamination levels were compared with the Kenya standards relevant for each milk product (KEBs).

4.0 Results

4.1 Total viable bacterial counts from fresh milk and other milk products

The prevalence of TVC isolated from milk and milk products is shown in Table 1. The total viable count (TVC) were enumerated and detected in 100% of the milk samples collected in all the sites. A significant statistical variation ($P \leq 0.05$) in the contamination level of TVC among the different milk products was observed in samples collected from Karen, Kibera and Langata.Of the samples collected in Karen, Ice cream had the highest contamination level (3.26log $_{10}$CFU ml $^{-1}$) followed by fresh milk 2.79 log $_{10}$ CFU ml $^{-1}$), while yoghurt samples collected from Kibera had the highest levels of contamination(3.04 log $_{10}$ CFU ml $^{-}$1) followed by yoghurt (2.77log $_{10}$ CFU ml $^{-1}$). Ice cream samples from Langata had the highest contamination levels at 4.35 log $_{10}$ CFU ml $^{-1}$ followed by yoghurt samples with contamination levels of 3.24 log $_{10}$ CFU ml$^{-1.}$On average when comparing milk and milk product samples, ice cream samples were found to be contaminated (3.46 log $_{10}$ CFU ml $^{-1}$) compared to other milk products. With the standard TVC for yoghurt, fresh milk and ice cream set at 6.0 log$_{10}$CFU by the Kenyan Bureau of Standards (KEBS) (Wanjala et al., 2017), the current findings indicated counts that were within the acceptable range. For each product, TVC is always available but you must compare with maximum allowed in standard before you lay claim to contamination.

Insert table 1

Values followed by the same letter (s) are not significantly different at $P \leq 0.05$ according to the Duncan's multiple range test.

4.2 Isolation and identification of total *Staphylococcus aureus*from fresh milk and other milk products

Table 3 illustrates the prevalence of *Staphylococcus aureus* investigated in the 36 samples examined. Overall, *Staphylococcus aureus* was detected in 33.3% of the milk and milk products. However, in Karen, *S. aureus* was not detected in milk products such as cheese, yoghurt and ice cream while in Kibera *S. aureus* was not detected in cheese and ice cream. In Langata, *S. aureus* was only detected in ice cream samples.

Insert Table 2

4.3 Isolation and identification of total *E. coli* from fresh milk and other milk products

The overall prevalence of *E. coli* in milk and milk products was 41.6% with a mean count of 0.34 $\log_{10}$ CFU ml^{-1} in Karen, 0.07 $\log_{10}$ CFU ml^{-1} in Kibera and 0.11 $\log_{10}$ CFU ml^{-1} in Langata. A significant difference ($P \leq 0.05$) in the occurrence of *E.coli*among the different products was observed in samples collected from Karen. However, there was no statistically significant difference in the levels of contamination between milk products collected from Kibera and Langata Wards. Of the samples collected in Karen, Ice cream had the highest contamination level of *E. coli* in all the sites with an average contamination level of 0.48 $\log_{10}$CFU ml^{-1}). Fresh milk, cheese and yoghurt samples from Kibera and Langata had no *E. coli* contamination. However, in Karen, only yoghurt was found to have no *E. coli* contamination.

Insert Table 3

Values followed by the same letter (s) are not significantly different at $P \leq 0.05$ according to the Duncan's multiple range test.

Insert Table 4

The standard for TVC, and *E. coli*according to KEBS KS ISO 4833-1, and KS ISO 11290-1 test methods are 6.0 log 10CFU and NIL values respectively. For the case of KS ISO 4833-1 test for *S.aureus*, the standard is set at NIL value for sterilized and pasteurized milk products.

5.0 Discussion

Food contaminants are important factors contributing to the high incidence of food borne disease in developing countries.The Kenya standards for the milk products; KS EAS 69: 2019 Pasteurized milk specification , KS EAS 33: 2019- Yoghurt specification , KS EAS 70: 2019- Dairy ice cream specification, and KS EAS 28 1: 2019- Cheese general requirements specification, gives the microbiological limits for each of the products, the maximum allowable counts for TVC in any of the milk products, for ice cream it should not exceed 4 × 104 cfu/g and in pasteurized milk it's capped at 3 × 104 cfu/g respectively all the standards give the limit for *E.coli*, *Staphylococcus aureus* and *Listeris monocytogenes* are absent in 25g.

5.1 TVC

The current findings shows that the total viable bacterial count (TVC) were enumerated and detected in 100% of the milk product samples collected in all the sites. Even though the contamination levels differed among the products and between the sites they were all within the set limits by the KEBS standards with regards to TVC. This outcome depicts those of Nur *et al*., (2021) where all the pasteurized milk had high bacterial load ranging from 2.17×10^3 to 3.84×10^3cfu mL-1. The same results were reported by Hasan *et al*., (2015) and Wanjala et al., (2017)where various quantities of TVC were isolated from different sources. However, these results differ those reported byWanjala et al. (2017)where the average TVC in raw milk collected from rural, urban and slum areas of Nairobi were 7.57, 7.52 and 8.18log10cfu/ml. The same above-mentioned findings were reported by Bhatnagar *et al*. (2007); Karthikeyan and

Dhanalakshmi (2010); Karthikeyan and Pandiyan (2013), however, the authors reported variations in number of total viable counts. According to Mendonca *et al.* (2020) though TVC is not a pathogen, their presence may increase the chances of the food having pathogenic microorganism because it raises doubts on the level of GMP implementation.

The occurrence of bacteria is of clinical significance and implies that these products can pose health risk to consumers. Milk processing handled in unhygienic conditions supports the growth of pathogenic microorganisms leading to contamination of milk products. Thus, this study indicates an improvement in the milk handling and hence improvement in milk quality. It is however important to note that the highest TVC contamination was observed in sampled collected from Langata and not Kibera however, there was not significant difference between the sites. The finding contradicts those of Wanjala *et al*., (2017) where the highest TVC contamination was recorded slums while the lowest count was detected in urban Nairobi.This implies that milk contamination may be starting from the farms and collection centers and as such milk and milk products within the county may have contaminated. However, companies manufacturing milk products must adhere to stricter inspection and better management practices. Mehmeti *et al*., (2017) suggests a frequent microbial analyses and the findings shared with farmers so that they can improve on their hygiene practices.

5.2 *E. coli*

Findings from the current study show that the overall prevalence of *E. coli* in milk and milk products was 41.6% with a mean count of 0.34$\log_{10}$ CFU ml $^{-1}$ in Karen, 0.07 $\log_{10}$ CFU ml $^{-1}$ in Kibera and 0.11 $\log_{10}$ CFU ml $^{-1}$ in Langata. However, significant difference ($P \leq 0.05$) in the occurrence of *E.coli* among the different products was only observed in samples collected in

Karen. The results reported in this study are similar to those reported by Miranda *et al*. (2009), Berhe *et al*. (2020) and Tanih *et al*. (2015)where E. coli, *S. aureus, L. monocytogenes* and *Salmonella* was detected. In their findings, Tanih *et al*. (2015) reported *E. coli* as the most detected pathogen followed by *S. aureus*. Rai *et al*., (2020) working with milk samples from Kathmandu District, reported that nearly half of the samples showed the presence of *E. coli*. Pathogenic *E. coli* has been shown to be an important pathogen causing outbreaks of acute diarrhea especially in developing countries (Vugia*et al*., 2010; Boisen *et al*., 2012; Rai *et al*., 2020) and thus their presence in the milk should not be overlooked. According to Kwenda (2015),*E. coli* should not be present in a well-prepared milk product such as cheese as high acidity of the fermented product should restrict their survival. Therefore, the presence of *E. coli* and any other microorganisms suggest that slow acidity development may have allowed the build-up of *E. coli*. It is important to note that out of all the milk products, ice cream samples had high incidences of *E. coli* than any other. According to Verraes*et al*., (2015) *L. monocytogenes*, *S. aureus* and*E.coli* are the main microbial hazards that are found in ice cream. The presence of *E. coli* and other microbes in ice creams indicates that the preparation process has not been done effectively or post process contamination might have occurred (Pal *et al*., 2016). According to Osamwonyi*et al.* (2011) possible sources of these pathogenic microorganisms in ice cream include raw materials used for the composition of ice cream such as separated milk and milk powder, cream, flavoring, coloring substances, stabilizers.

5.3 *Staphylococcus aureus*

Overall, *Staphylococcus aureus* was detected in 33.3% of milk and milk products.However, the numbers could not be quantified. In Karen, *S. aureus* was not detected in milk products such as cheese, yoghurt and ice cream while in Kibera *S. aureus* was not detected in cheese and ice

cream. These findings are similar to those reported by Latha *et al*. (2017) and Dai *et al*. (20919) where high prevalence of *S. aureus* was reported, however, the prevalence of *S. aureus* in this study is lower. This may be due to the fact that the samples were branded samples sourced from various supermarkets. The results reported here concur with those of Rall *et al*. (2008), Gundogan *et al*. (2006) and Holi *et al*. (2021) where various samples were found positive for *S. aureus*. *Staphylococcus aureus* is an environmental contaminant that is commonly found on surfaces, and it may result from poor hygiene practices such as inappropriate cleaning of surfaces or using contaminated water for cleaning.*Staphylococcus aureus* is generally present in the skin and mucous membrane another pathogen that can be used to measure the sanitary conditions in which food is produced and handled.

6.0 Conclusion

The TVC counts isolated in all the samples were within the set limits by the KEBS standards. However, with the microbial counts for *E.coli*were above the set standards by food safety regulatory bodies. Consequently, the consumption of microbiologically unsafe milk and milk products pose a significant health risk to consumers due to their potential to cause illnesses. With a projected increase in the production and consumption of dairy products in Kenya and the whole of Africa, production and handling practices are likely to play a key role in the safety of these products. Detection of *E. coli* and *S. aureus* foodborne pathogens in milk and milk products, even if in few samples indicate possible lapses in industrial implementation of food safety management systems.

7.0 Recommendations

There is need to improve the microbial quality of milk and milk products by employing measures that will establish proper management practices to ensure improved hygiene, good manufacturing practices and food systems that will help to minimize microbial contamination. The processing plants need to improve on the implemented food safety management systems to ensure that the products processed are of the highest microbiological quality. Additionally, regulators need to intensify on market surveillance and product testing to protect the consumers from getting contaminated products.

9.0 References

Bhatnagar, P., Khan, A.A., Jain, M., Kaushik, S. and Jain, S.K. (2007). Microbiological study of khoa sold in Chambal region (Madhya Pradesh): A case study. Indian Journal of Microbiology 47, (263-266).

Karthikeyan, N. and Dhanalakshmi, B. (2010). Hygienic quality of Indian sweet milk products from different sources. Bangladesh J. Microbiol. 27, (2), 32-37. 7.

Karthikeyan, N. and Pandiyan, C. (2013). Micobial quality of Khoa and khoa based milk sweets from different sources. Int. Food Res. J. 23(3), 1443-1447. 8

Parseelan, A., Muthu, S., Kannan, P., Ayyasamy, E., & Narayanan, R. (2019). Aerobic Plate Count of Milk and Dairy Products Marketed in Different Zones of Chennai. International Journal of Livestock Research, 9(3), 97-102. doi: 10.5455/ijlr.20180711104721

Pal, M., Mulu, S., Tekle, M., Pintoo, S. V., & Prajapati, J. (2016). Bacterial contamination of dairy products. Beverage and food world, 43(9), 40-43.

Verraes, C., Valemynck, G., Weyenberg, S. V., De Zutter, L., Daube, G., Sindic, M., Uyttendaele, M. and Herman, L. 2015. A review of the microbiological hazards of dairy products made from raw milk. International Dairy Journal 50:32-44.

Akinyemi, M. O., Ayeni, K. I., Ogunremi, O. R., Adeleke, R. A., Oguntoyinbo, F. A., Warth, B., & Ezekiel, C. N. (2021). A review of microbes and chemical contaminants in dairy products in Sub- Saharan Africa. Comprehensive Reviews in Food Science and Food Safety, 20(2), 1188-1220.

Vugia D, Cronquist A, Cartter M, Tobin-D'Angelo M, Blythe D, Smith K, Lathrop S, Morse D, Cieslak P, Dunn J. Preliminary FoodNet Data on the incidence of infection with pathogens transmitted commonly through food—10 States, 2008. MMWR Morb Mortal Wkly Rep. 2010;59(14):418–422.

Hossain TJ, MK Alam and D Sikdar, 2010. Chemical and Microbiological Quality Assessment of Raw and Processed Liquid Market Milks of Bangladesh. Research J. Dairy Sci., 4: 28-34.

Kwenda, A., Nyahada, M., Musengi, A., Mudyiwa, M., &Muredzi, P. (2014). An investigation on the causes of Escherichia coli and coliform contamination of cheddar cheese and how to reduce the problem (A case study at a cheese manufacturing firm in Harare, Zimbabwe).

Nur, I. T., Ghosh, B. K., Urmi, J. N., Akter, D., & Ema, E. I. Microbiological Quality Assessment of Milk and Milk Products Along with their Packaging Materials Collected from a Food Industry in the Dhaka Division.

Wanjala, G. W., Mathooko, F. M., Kutima, P. M., &Mathara, J. M. (2017). Microbiological quality and safety of raw and pasteurized milk marketed in and around Nairobi region. African Journal of Food, Agriculture, Nutrition and Development, 17(1), 11518-11532.

Hasan, M. A., Islam, M. A., Mahmud, M. S., Uddin, A. A., & Ahmed, S. (2015). Microbial analysis of raw and pasteurized milk from selected areas of Dinajpur, Bangladesh. Asian Journal of Medical and Biological Research, 1(2), 292-296.

Annal Selva Malar, P., Sekar, M., Porteen, K., Elango, A., & Narayanan, R. Aerobic Plate Count of Milk and Dairy Products Marketed in Different Zones of Chennai.

Akinyemi, M. O., Ayeni, K. I., Ogunremi, O. R., Adeleke, R. A., Oguntoyinbo, F. A., Warth, B., & Ezekiel, C. N. (2021). A review of microbes and chemical contaminants in dairy products in sub- Saharan Africa. Comprehensive Reviews in Food Science and Food Safety, 20(2), 1188-1220.

Pal, M., & Jadhav, V. J. (2013). Microbial contamination of various India milk products. Beverage and Food World, 40(12), 43-44.

Tanih, N. F., Sekwadi, E., Ndip, R. N., &Bessong, P. O. (2015). Detection of pathogenic Escherichia coli and Staphylococcus aureus from cattle and pigs slaughtered in abattoirs in Vhembe District, South Africa. The Scientific World Journal, 2015.

Berhe, G., Wasihun, A. G., Kassaye, E., &Gebreselasie, K. (2020). Milk-borne bacterial health hazards in milk produced for commercial purpose in Tigray, northern Ethiopia. BMC Public Health, 20(1), 1-8.

Miranda, J. M., Mondragón, A., Vázquez, B. I., Fente, C. A., Cepeda, A., & Franco, C. M. (2009). Influence of farming methods on microbiological contamination and prevalence of resistance to antimicrobial drugs in isolates from beef. Meat science, 82(2), 284-288.

Latha C, Anu CJ, Ajaykumar VJ, Sunil B (2017) Prevalence of Listeria monocytogenes, Yersinia enterocolitica, Staphylococcus aureus, and Salmonella enterica Typhimurium in meat and meat products using multiplex polymerase chain reaction, Veterinary World, 10(8): 927-931

Rall,V.L.,Vieira,F.P.,Rall,R.,Vieitis,R.L.,Fernandes,A.Jr.,Candeias,J.M.,etal. (2008). PCR detection of staphylococcal enterotoxin genes in Staphylococcus aureus strains isolated from raw and pasteurized milk. Vet. Microbiol. 132, 408–413.doi:10.1016/j.vetmic.2008.05.011

Dai, C. F., Wen, J., Lu, X. U., Huang, G. X., Sun, H., Hu, Z. K., *et al*. (2009). Investigation of a case on milk product poisoning caused by Staphylococcus aureus.Chin.J.FoodHyg.03,262–264.

Gündoˇgan, N., Citak, S., and Turan, E. (2006). Slime production, DNase activity and antibiotic resistance of Staphylococcus aureus isolated from raw milk, pasteurised milk and ice cream samples. Food Control 17, 389–392. doi:10.1016/j.foodcont.2005.01.006

Figures and tables

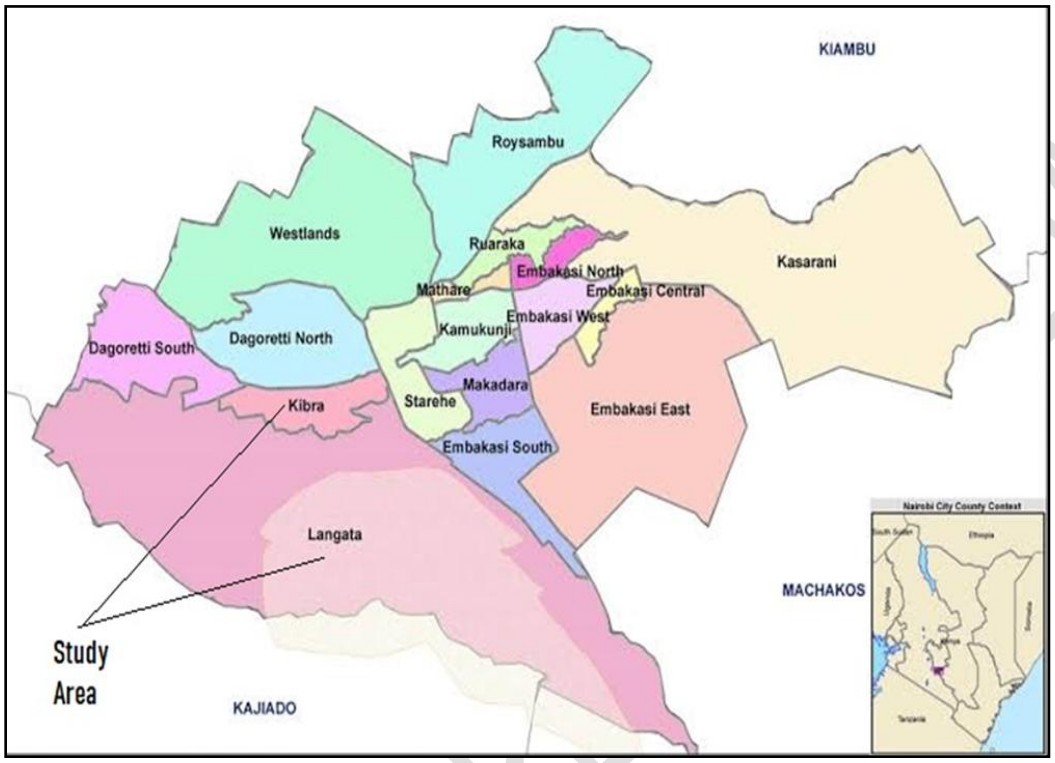

Figure 1: Location of study areas in Nairobi County ©ResearchGate (2020)

Table 1: Prevalence and contamination levels of TVC (log $_{10}$ CFU ml $^{-1}$)in fresh milk and other milk products collected from various sites in Nairobi County.

	Location			
Milk and milk Products	Karen	Kibera	Langata	Mean
Fresh milk	2.79 ± 0.08^{ab}	2.74 ± 0.23^{ab}	2.25 ± 0.07^{b}	2.59 ±0.30^{b}
Cheese	2.66 ± 0.13^{ab}	2.39 ± 0.12^{b}	2.41 ± 0.07^{b}	2.49 ± 0.15^{b}
Yoghurt	2.31 ± 0.10 ^{b}	3.04 ± 0.14^{a}	3.24 ± 1.3^{ab}	2.86 ±0.49^{ab}
Ice cream	3.26 ± 0.08^{a}	2.77 ± 0.12^{ab}	4.35 ± 0.78^{a}	3.46 ± 0.81^{a}
Mean	2.75 ± 0.39	2.74 ± 0.27	3.06 ± 0.96	2.85 ± 0.46

LSD (P≤ 0.05)	0.62	0.42	1.53	0.69
CV (%)	22.8	22.8	0.92	0.18

Table 2: Prevalence and contamination levels of *Staphylococcus aureus* (log $_{10}$ CFU ml $^{-1}$)in fresh milk and other milk products collected from various sites in Nairobi County

	Location		
Milk and Milk Product	**Karen**	**Kibera**	**Langata**
Fresh milk	Detected	Detected	ND
Cheese	ND	ND	ND
Yoghurt	ND	Detected	ND
Ice cream	ND	ND	Detected

ND- Not detected

Table 3: Prevalence and contamination levels of *E. coli* (log $_{10}$ CFU ml $^{-1}$)in fresh milk and other milk products collected from various sites in Nairobi County

	Location			
Milk and milk Products		Kibera	Langata	Mean
Fresh milk	0.46ab	0.00a	0.00a	0.15a
Cheese	0.16ab	0.00a	0.00a	0.05a
Yoghurt	0.00b	0.00a	0.00a	0.00a
Ice cream	0.73a	0.28a	0.43a	0.48a
Mean	0.34	0.07	0.11	0.17
LSD (*P<0.05*)	0.58	0.58	0.58	0.58

CV (%)	200.70	200.70	200.70	200.70

Table 4: Microbiological criteria for milk and milk products ($Log_{10}CFU$)

Microorganisms	Mean ($cfug^{-1}$)			Interpretation of microbiological quality [a]
	Karen	Kibera	Langata	
TVC	2.75	2.74	3.06	Acceptable [b]
E. coli	0.34	0.07	0.11	Satisfactory
S. aureus	ND	ND	ND	Satisfactory