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Implementation of Good Manufacturing Practices in Milk Processing Companies in Nairobi County and Microbial Contamination of Milk and Milk Products

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Good manufacturing practice involves a series of measures to be adopted by the food industries in order to guarantee the safety and conformity of food products to specific regulations. Even though good manufacturing practices are vital systems in food safety and is associated with minimum sanitary and processing requirements for the food industry, only a few studies have reported GMP implementation by small milk processing companies. Therefore, the present study was undertaken in milk processing firms to evaluate the implementation of good manufacturing practices for control of microbial contamination in milk and milk products. Purposive, random and stratified sampling techniques was used to identify milk processing companies. Ten processing facilities were purposively sampled for the study. The representatives were interviewed, using a pretested

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questionnaire and data was collected and analyzed. All the processors had qualified personnel handling milk and milk products with a daily processing capacity of 20000-30000 litres. It was observed that the processors complied with all regulatory and licensing requirements and had in place critical process controls with majority indicating pasteurization at temperatures ranging from 80-90^{o}C as the most common method. The processors had several food safety management systems such as ISO 22000, GMPs, and HACCP which were handled by trained and competent staff. It was observed that all the processors tested for total viable counts (TVC), and *E. coli* while only 50% and 33.3% of the processors tested for *S. aureus* and *L. monocytogenes* respectively. Furthermore, the processors (33.3%) reported *E. coli* as the main contaminant while *L. monocytogenes* were not detected. A majority (83.3%) had well-documented cleaning programs and had a system of controlling cross contamination which was enforced through different colour codes (66.7%), memos and notices (16.7%) and through colour coding of processing equipment (16.7%). In conclusion, the present study discovered that milk processors had implemented good manufacturing practices (GMP) and conformed to good processing practices.

Keywords: GMP; HACCP; ISO; pasteurization; regulatory requirements; milk processing systems.

1. INTRODUCTION

In Kenya, 5 billion litres of cow's milk is produced annually in Kenya and out of those 600 million litres is processed and formally marketed in various towns, Nairobi accounts for the largest percentage of the formal market (KDB, 2018). In Oct 2020, milk consumed in Nairobi alone accounted for 59,710,445 litres of the total amount produced. Milk and milk products are main sources of dietary nutrition for all age groups especially, children, pregnant women, sick and the immune-compromised individuals (UNICEF, 2019). Because of its nutritive value, milk is considered as one of the most important diet items of many people. The demand for safe and high-quality milk has forced dairy producers, retailers and manufacturers to produce and market safe milk and milk products [1].

Raw or processed milk is good medium for growth of numerous microorganisms, however, the presence of these hygiene indicator micro-organisms in processed milk and milk products is an indication of inefficient processing methods, poor handling and post processing contamination which then raises concerns on the safety of product for consumption (Buchanan & Oni, 2012). This shows that regardless of the kind of processing a food goes through if at the end of it all it's contaminated with the indicator microorganism the food carries with it the risk that can cause an illness. Worldwide, the presence of microorganisms has been used as hygiene indicator and as a measure of the suitability of the processing environment, personnel hygiene, effective pasteurization process, good manufacturing practices (GMP), Good sanitation processes or proper post processing handling (Metz et al., 2019). The most common hygiene indicators microorganisms used for foods and drinking water include the *Total viable Count* (TVC), *coliforms*, *Enterobacteriaceae spp* including *Escherichia coli, Staphylococcus aureus, Listeria Spp* and the yeasts and molds (Martin et al., 2016). *Total viable count* (TVC) is one of the most used hygiene indicator tests and TVC counts exceeding a given level usually indicate that sanitation of the environment or equipment was inefficient or not properly done which is generally a good guide in determining if good manufacturing practices have been implemented (Metz et al., 2019; (O'Grady et al., 2020). It's also used to gauge the organoleptic acceptability of the food. Total viable microorganisms in themselves are not pathogenic but may give a clear indication as to the safety level of the food. The higher the TPC levels, the higher the chances that the pathogenic microorganism can be present in the food because it puts doubts on the level of GMP implementation (Mendonca et al., 2020).

Combination of interventions is needed to control *E. coli, S. aureus*, and *Listeria monocytogenes* and the other hygiene indicator organism's contamination (CAC/GL 61, 2007). There is need to address the entire Milk processing systems not just focusing on the effectiveness of the pasteurization as a control, these include, management of sourcing and handling of the milk as a raw material, control of pasteurization, GMPs that control cross contamination, effective cleaning and sanitation procedures, verification methods for cleaning effectiveness, Trainings, Environmental pathogens control program and finally analysis of products prior to dispatch to the market as required by the codex guidelines on hygiene in milk processing (CAC/RCP 57-2004).

Observation of the general layout of the facility is also critical because the flow of air is a contributing factor to *Listeria* spread within the facility [2] (Piet et al. 2016). The control and prevention of contamination of food products with indicator microorganism require a complete focus on the good manufacturing practices (GMPs): all food handlers must undergo a food handlers' medical exam at least once every six months, they should practicing good hand hygiene ensuring that their hands are cleaned and sanitized before handling any food. Processing environment must be clean and equipment should also be clean and sanitized to avoid cross contamination (Lee et al. 2017). The main aim of the research was to determine if milk processing companies have implemented GMPs in milk processing systems necessary for the control of *TVC, E. coli, Staphylococcus aureus and Listeria monocytogenes* micro-organisms contamination in milk and milk products.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out in Karen, Kibera and Langata Sub- Counties of Nairobi County, Kenya (Fig. 1). These locations were purposively chosen because they have glaring contrast in living standards ranging from economically stable households in Karen and Langata and sprawling slums of Kibera characterized poor living conditions. Karen, Langata and Kibera are located to the Southwest 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 ethnic diverse communities with high levels of poverty, crime and lack of common basic amenities (Ochungo et al. 2019).

2.2 Study Population and Sampling

The population of the study included the processors in Nairobi County. Purposive, random and stratified sampling techniques were used. These milk processing plants: large, mid-sized and mini processors process milk and milk products: (Fresh milk, yoghurts, Ice cream and Cheese) meant for sale within Nairobi County.

2.3 Sample Size Determination for Processors

Simple random sampling technique was used in selecting the sample for the milk processing systems for milk and milk products. Cluster sampling per sub-county was used to obtain ten processing facilities registered by Kenya Dairy Board (KDB) within Nairobi and its environs. Exhaustive sampling was done for cheese and Ice cream processors, because the population size was small, all of them were included in the study.

2.3.1 Inclusion criterion

The eligible participants were all processing facilities that are licensed by KDB, are within Nairobi County and its environs. Processes and packages milk and milk products mainly meant for sale in Nairobi County.

2.3.2 Exclusion criterion

Any Milk and milk products processers not licensed by KDB, not within the Nairobi County and its environs and whose products are not packaged for sale in the retail market within Nairobi County.

2.4 Data Collection

Questionnaires were distributed in each of the factory located in Nairobi. The questionnaire was divided into two sections with the first one associated with general information, and the second one included the entire Good Manufacturing Practices (GMP) check-list related to the Kenyan standard. The representatives were interviewed, to determine the implementation of the GMPs in the processing systems on the facility. A Pretested questionnaire using the Open Data Kit (ODK) developed by Get ODK on a Samsung mobile phone that recorded the information online was used. Data was collected to assess processors' knowledge on *Listeria monocytogene* and their occurrence in the different milk products. Conformity to milk regulatory requirements was also determined through enquiry of the food systems management systems in place.

2.5 Statistical Data analysis

Both quantitative and qualitative data collected were coded and entered the computer using Excel data sheet management and analyzed by SPSS version 20.0. Data analysis was done to determine the food safety management systems in place, such as HACCP, ISO 22000, and GMPs. Inferential analysis was done to determine the processors' knowledge on these systems to their level of education.

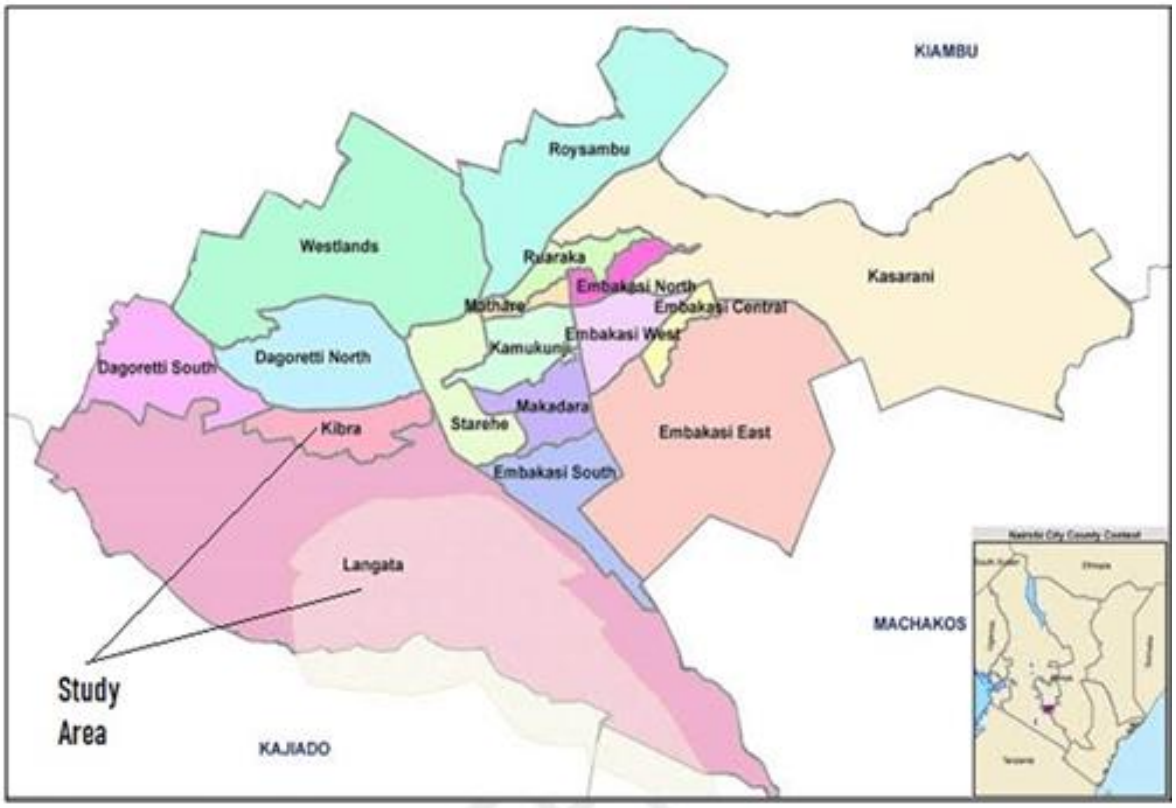

Fig. 1. Location of study areas in Nairobi County ©ResearchGate (2020)

3. RESULTS

3.1 Milk Processors Profile

Survey on implementation of good manufacturing practices revealed that most of the respondents were working as quality assurance analysists (50%) followed by quality control managers (Table 1). These companies were involved in the manufacture of various milk and milk products with majority of them being involved in the manufacture of fresh milk and yoghurt (66.7%). Other products include cheese, butter, ice cream and whipping cream. The results also show that many of the company had processing capacity of between 20000 – 30000 liters of milk per day.

3.2 Compliance and Regulatory Requirement

On compliance with regulatory requirements, all the facilities were licensed by public health, Kenya Dairy Board, and their products approved by Kenya Bureau of Standards and were also regularly inspected by the regulatory bodies (Table 2). On the other hand, the results show that all the workers within the facilities had undergone food handlers' medical tests and it was also a requirement that employees who fail medical test isolate themselves.

3.3 Process controls

Observations with regard to critical controls showed that majority of the companies (50%) identified pasteurization, closely followed by freeze storage (33.3%) as a measure to inhibit microbial growth. It was also noted that all the staff in the critical areas were trained on various parameters to take note of. All the raw milk was pasteurized at either temperature ranging from 80-85^{o}C (50%) or 86-90^{o}C (50%). When they were asked about pasteurized efficiency, 66.7% of the respondents indicated it was efficient while 33.3% suggested it was not. The respondents (83.3%) also indicated incidences of pasteurization failures. All the respondents indicated that temperatures were monitored, records maintained and the tools for monitoring temperatures were calibrated by accredited laboratories. Majority (66.7%) of the respondents specified that calibration of the equipment was done annually, and the record of every calibration conducted maintained.

3.4 Safety of milk Processing Systems

The results of the safety of milk processing systems are in Table 4. All the companies had implemented food safety management systems. The most popular systems in place were ISO 22000 (50%), GMP (33.3) and HACCP (16.7%). All the companies identified the most critical points in the systems and had their staff trained on critical control points.

3.5 Microbial Contamination

Out of the products sampled for microbiological analysis, 50% and 33.3% of the processors tested for *S. aureus* and *L. monocytogenes,* respectively (Table 6). Furthermore, when the respondents were asked if samples had been contaminated by either *E. coli* or *S. aureus* in the last six months, 33.3% of the respondents agreed to this statement and half of them reported *E. coli* as the main contaminant isolated. It was also noted that all the equipment installed for milk processing in the companies were tested for *L. monocytogenes* pathogen but were found not to have been contaminated. However, only 50% of the respondents performed *Listeria monocytogenes* testing on equipment. It was also observed that only 33.3% of the companies had facilities in place for testing and only 16.7% had received complaints from customers about food poisoning. All the staff were trained on the pathogenic microbes that would contaminate milk and milk products.

Table 1. Milk processors profile

Statement	Parameter	Percentage	STD. Dev
Employee position	QAM	33.3	0.98
	Quality Control	16.7	
	QAA	50.0	
Company Location	Kiambu	33.3	0.51
	Nairobi	66.7	
Female employees	1-100	50.0	1.16
	101-200	33.3	
	201-300	0.0	
	over 300	16.7	
Male employees	1-100	16.7	1.03
	101-200	16.7	
	201-300	50.0	
	over 300	16.7	
Products	Cheese	50.0	1.96
	Fresh milk	66.7	
	Yoghurt	66.7	
	Butter	16.7	
	Ice cream	16.7	
	Whipping cream	33.3	
Quantity of milk	1000-10000	33.3	1.16
	11000-20000	33.3	
	21000-30000	16.7	
	31000-40000	16.7	
Qualified Personnel	Yes	100.0	0.00
	No	0.0	

Table 2. Compliance to regulatory and licensing requirements by milk processors in Nairobi

Statement	Yes (%)	No (%)
Is the facility licensed by public health	100.0	0.0
Is the facility licensed by Kenya Dairy Board	100.0	0.0
Are the products approved by KEBS	100.0	0.0
All workers undergone food handlers' medical tests	100.0	0.0
Do you isolate employees who fail medical tests	100.0	0.0
Are you inspected by regulatory bodies	100.0	0.0

Table 3. Various process controls undertaken by milk processors in Nairobi

Statement	Yes (%)	No (%)	y
Have you identified critical processes in your facility	100.0	0.0	0.0
Staff in critical areas trained on parameters to observe	100.0	0.0	0.0
Are all raw milk used pasteurized?	100.0	0.0	0.0
Pasteurization temperature: 75-79	18.5	81.5	0.0
Pasteurization temperature: 80-85	30.0	70.0	0.0
Pasteurization temperature: 86-90	51.5	48.5	0.0
Is pasteurization efficiency tested	66.7	33.3	0.5
Are there incidents of failure of the pasteurization efficiency tests	83.3	16.7	0.4
Monitoring of processing temperatures	100.0	0.0	0.0
Are records of monitoring maintained	100.0	0.0	0.0
Are temperature monitoring devices calibrated by accredited labs?	100.0	0.0	0.0
Are records of calibration maintained?	66.7	33.3	0.8

Table 4. Milk processing systems and their safety

Statement	Yes (%)	No (%)	y
Has the plant implemented Food Safety Management system	100.0	0.0	0.0
Are there critical control points identified in the systems	100.0	0.0	0.0
Staff in operations trained on CCPs	100.0	0.0	0.0

Table 5. Tests on identification of various microorganisms contaminating milk and milk products

Statement	Yes (%)	No (%)	y
Are all end products tested for microbiol contamination	100.0	0.0	0.0
Is *TVC* analyzed	100.0	0.0	0.0
Is *E. coli* tested	100.0	0.0	0.0
Is *Staphylococus aureuas* tested	50.0	50.0	0.5
Is *Listeria Monocytogenes* tested	33.3	66.7	0.5
Has any sample tested positive to *E. coli, S. aureaus* in the last 6 months?	33.3	66.7	0.5
Has any product or equipment tested positive to *Listeria monocytogenes*	0.0	100.0	0.0
Does the facility have a pathogen testing program in place	33.3	66.7	0.5
Is *Listeria Monocytogenes* testing done on Equipment?	50.0	50.0	0.5
Have you ever received complaint from customers about Food Poisoning	16.7	83.3	0.4
Are the staff trained and aware of microbiological contamination	100.0	0.0	0.0

3.6 Cleaning and Sanitation

Majority of the respondents (83.3%) agreed to have documented cleaning program and applied food grade cleaning and disinfecting agents (Table 7). All the processors cleaned the processing equipment on daily basis while only 83.3% verified the efficiency of the cleaning done. However, all the processors (100%) had records of every cleaning done maintained. All the processors used water from the municipal council while 50% used water obtained from the boreholes. It was noted that water used was portable and was tested for microbial quality in the laboratory. On a positive note, results of water testing in the last six months had not been found to be contaminated with any microbial contaminant. Analysis was mainly done on coliforms (100%), TVC (66.7%) and on yeast and molds (16.7%).

3.7 Measure to Control Cross Contamination

All the processors had a system to control cross contamination and was enforced through means such as the use of different colour codes (66.7%), memos and notices (16.7%) and through colour coding of processing equipment (16.7%) (Table 8). It was also noted that movement restrictions were imposed on personnel and equipment within the facility in all the premises surveyed. All the premises surveyed had a separate area for handling raw

milk and pasteurized products, used disposable food grade gloves for handling open foods and installed designated hand washing areas.

3.8 Conformity to Good Manufacturing Practices

Various areas were considered when implementing GMP based on the basic requirements established by KEBS. The initial diagnosis of the milk processing plants on the implementation of GMP indicated an average of 78% of conformity. Among the areas that were assessed, licensing and hygiene depicted the highest percentages of conformity (Table 8). In addition, cleaning and sanitation, cross contamination, milk safety, microbial contamination and process control all had conformed to the standards requirement albeit at different levels.

4. DISCUSSION

4.1 Profiles of Milk Processors

Survey on implementation of good manufacturing practices revealed that most of the employees responsible for monitoring of the GMPs implementation for the milk processing were quality assurance analysists and quality control managers. This finding is in line with those reported by Idrees et al. (2016) where the employees graduated and had hazard analysis critical control point (HACCP and GMP) with a working experience of more than two years. Milk processing and operations personnel are required to have the necessary qualifications to ensure safety of food and that it has the appropriate identity, purity, strength, and meets consumer quality demands [2]

4.2 Processing of Milk Products

Of the total milk products, yoghurt and fresh milk were the most commonly processed products. Other products include cheese, butter, ice cream and whipping cream. These findings relate to those reported by Schneider (2018) who highlighted yoghurt and fresh milk as the most processed milk products in Nairobi. The dominance of these two products suggests that new milk processing companies must therefore advance the two products to attract more consumers. The majority of processors had a processing capacity ranging from 10000-20,000 litres of milk per day. This capacity seemed manageable suggesting that chances of contamination by pathogenic microbes was low.

4.3 Compliance to Regulatory Requirements

All the milk processing facilities were licensed by public health, Kenya Dairy Board, and their products approved by Kenya Bureau of Standards. The results found in this study is an indication of conformity to laid down regulations to ensure milk and milk products satisfy the highest expectation of the manufacturers and ultimately the consumers. According to the Kenya Dairy Board, licensing of milk handling premises is an important activity in regulation of the dairy industry as it facilitates regular inspection of such premises to ensure compliance to milk quality and safety requirements. The dairy industry in Kenya is regulated by various acts, regulations and guidelines and the enforcement of dairy standards and regulations involves operations against non-conformities. Requirements for hygienic and safe production of milk and milk products are obtained from Kenya Bureau of Standards and other international bodies such as Codex Alimentarius, the Food and Agriculture Organization (FAO) and international dairy federation. On the other hand, the employees had undertaken food handlers' medical tests and those who failed the medical tests were required to isolate. This finding is similar to those of Tesfaye et al. [3] where workers in a milk

Table 6. Documentation of cleaning and sanitation programs

Statement	Yes (%)	No (%)	y
Is there a documented cleaning program in place	83.3	16.7	0.4
Do you use food grade cleaning and disinfecting agents	83.3	16.7	0.4
Is cleaning efficiency verified?	83.3	83.3	0.4
Are Records of cleaning maintained	100.0	0.0	0.0
Is the water quality tested in the lab for microbiological quality?	100.0	0.0	0.0
Has the water failed the tests in the last 6 months	0.0	100.0	0.0

Table 7. Various control measures in place to manage cross contamination

Statement	Yes (%)	No (%)	y
Do you have a system for controlling cross contamination	100.0	0.0	0.0
Movement restriction in the facility and colour coding practiced.	100.0	0.0	0.0
Do you have a separate area for handling raw milk and pasteurized products?	100.0	0.0	0.0
Are food grade gloves used in handling open food?	100.0	0.0	0.0
Are there designated hand wash areas?	100.0	0.0	0.0

processing facility are required to yearly undertake health check and obtain the health certificate. The law should be such that medical examination of the employees should be carried out epidemiologically otherwise medical checkup should be done bi-annually and personnel found to be infected should stay away from designed areas until medically fit.

Table 8. Mean percentage of conformities found in various milk processing firms during the implementation of GMP

Areas of conformity	Conformity	Non-Conformity
Process control	60.8b	39.2a
Microbial contamination	63.2ab	36.8ab
Milk safety	66.7ab	33.3ab
Cross contamination	77.8a	22.2b
Cleaning and sanitation	78.1a	21.9b
Licensing	100.0a	0.0c
Hygiene	100.0a	0.0c
Mean	78.1	21.9
LSD (P= 0.05)	15.2	15.2

4.4 Process Controls

Observations with regard to critical controls showed that all the companies had in place critical processes such as pasteurization, cleaning and sanitation, cold storage and sterilization and all the staff were trained in each critical area. The dairy industry is composed of various interlinked processes such as pasteurizing, homogenizing, ageing, flavoring, freezing and packaging [4]. The implementation of processes such as pasteurization to improve the milk process optimization is of importance in each facility handling milk [5]. For instance, pasteurization is one of the main critical control points (CCPs) in the milk industry that helps in destroying potential harmful pathogens. It is also important that milk is stored at low temperatures below 10^{o}C to arrest the growth of bacteria. Cooling milk has special significance since freshly drawn milk is about 38^{o}C which is highly suited for bacterial growth.

All the raw milk was pasteurized at either temperature ranging from 80-85^{o}C (50%) or 86-90^{o}C. On pasteurization efficiency, 66.7% of the respondents indicated it was efficient while 33.3% suggested it was not. The respondents (83.3%) also indicated incidences of pasteurization failures. All the respondents indicated that temperatures were monitored, records maintained and the tools for monitoring temperatures were calibrated by accredited laboratories. Cifeli et al. [6] defines pasteurization as the process of heating raw milk at 72^{o}C for a period of 15 seconds followed by rapid cooling while according to Dhotre [7] pasteurization is recognized by specific temperature and time combination. Therefore, the temperatures and time combination selected should be high enough to destroy all pathogenic microorganisms in milk and at the same time low enough not to maintain the heat sensitive milk constituents. When the pasteurization is performed efficiently, the process destroys all pathogenic bacteria, yeasts, molds, and almost all other non-pathogenic bacteria that may be associated with non-pasteurized milk (Ewaschuk and Unger, 2015). Thus, this process is considered very efficient and effective method of increasing milk shelf life.

4.5 Food Safety Management Systems

The results of the safety of milk processing systems shows that all the companies had implemented food safety management systems such as ISO 22000, GMP and HACCP [8]. All the companies identified the most critical points in the systems and had their staff trained on critical control points. This shows that majority of the milk processors conformed with the required good manufacturing practices, therein ensuring the identity, strength, and quality of their milk and milk products while reducing facility losses

associated with microbial contaminations. This finding concurs with those of Tutu and Anfu [9] where majority of the food manufacturing companies had some form of food safety systems (FSMS) and operated on either operated system based on ISO 22000 standards or Good Manufacturing Practices. Milk safety systems are associated with activities such as good hygienic practices, good manufacturing practices and Hazard Analysis and Critical Control Point System (HACCP) [10]. Rotaru et al. [11] indicated that among the Quality Assurance (QA) systems, Good Manufacturing Practices (GMPs), Good Hygiene Practices (GHPs), Good Agricultural Practices (GAPs) and Hazard Analysis are the most utilized currently. Having a functional quality control system is of significant importance since they bring about improvement in food safety (Abdelgadir et al., 2016); [12]. Critical Control Points are the commonly applied systems in both food and dairy industries. Integrated Management systems such as ISO 22000:2005 are also accessible for producers. Tamine (2009) further clarifies that HACCP approach is science-based quality control system designed to be implemented in the food and dairy sector while good manufacturing practices are minimum sanitary and processing requirements for food processing companies. The GMPs ensures adherence to all quality and safety basic requirements such as elimination, prevention, minimization of product failures consistent product safety [11]. The implementation of these systems by the milk processors indicated an improvement in the performance of by these milk processors. For instance, integration of HACCP as part of quality system provides safe food products and also ensure a better and more effective implementation of the entire quality system something that is also offered by ISO 22000: 2005 [13].

4.6 Measures to Control Cross Contamination

All the companies had put in place personal hygiene, cleaning and sanitation, waste management and pest control facilities. The results herein are supported by findings of Pal et al. [14] which emphasized the importance of hygienic practices in processing which improved the microbial quality standards of milk and milk products. The results also conform to those of Parafin et al. [15] where large scale milk processors had facilities for disinfection, rodent control, and access control. However, our results contradict those of Abdegadir et al. (2016) where they reported lack of regular cleaning and sanitation, collection of waste, and insect control in milk processing plants. Stringent administration of hygienic practices involving personal hygiene, sanitation, waste management and pest control are important to improve the microbial safety of the milk products, and ultimately reduce the hazards related to microbes. It is also important that proper packaging and storage are done under strict hygienic conditions. Mortajeni et al. [16] opine that provided that hygienic measures are taken to prevent pre and post and even cross-contamination, milk and dairy products can be produced and consumed safely. According to Te Giffel. [17] stages in milk processing must be properly and hygienically handled to assure quality of milk and milk products. Adherence to these basic practices such as good agricultural practices and good manufacturing practices are the first steps towards achieving food safety in the dairy industry.

With regards to microbial contamination, the results showed that all the products were tested for total viable counts (TVC), and *E. coli.* However, only a few of the processors tested for *S. aureus* and *L. monocytogenes* respectively. It was also noted that some samples were contaminated by either *E. coli* or *S. aureus* in the last six months and *E. coli* was isolated from samples as the contaminant. Our findings agree with those of Pal et al. [14] where a large number of microbes causing quality degeneration in milk and milk products were identified. According to Pal et al. [14] microbial contamination of milk and milk products can occur as a result of contaminated utensils, environment, handlers, and even additives. Microbial identification in milk products offer evidence regarding the hygienic practices implemented during the product preparation, and subsequent packaging, handling, storage, and distribution [14]. The isolation and identification of *E. coli* pathogen in the current study indicates risks associated with milk and milk products and suggests failure in quality assessment systems. The contamination of samples with *E. coli* was probably contributed by different handlers whose hygiene and cleanliness varied, water or inefficiency in the utilization of internationally approved tests to ensure application of approved practices and standards [10]. However, Parafin et al. [15] credited the presence of E. coli and other microbes to ineffective disinfection for personnel and equipment. Yuen et al. (2012) showed that

presence of *E. coli* in milk and milk products is likely to occur when workers practice poor hygiene and sanitation procedures something that contradicts our findings similarly, products manufactured under unsanitary conditions are expected to be contaminated

It was also observed that only a few of the companies had facilities for testing and only 16.7% had received complaints from customers about food poisoning. All the staff were trained on the pathogenic microbes that would contaminate milk and milk products. The current study findings indicate that milk processors perceived *L. monocytogenes* as very risky and conducted tests to determine if it contaminated the equipment. This shows that the identified milk processors heed Mtimet et al. (2015) call of processors having abundant knowledge on various pathogenic microbes and the need to observe standards to prevent milk contamination.

4.7 Conformity to Good Manufacturing Practices

Majority of the milk processors had well documented cleaning program, used food grade cleaning and disinfecting agents, and cleaned the processing equipment on daily basis. The results found herein concurs with those of Tesfaye et al. [3]. The authors indicated that all equipment and contact surfaces should be clean and should properly maintained so as to minimize accumulation dirt and in return reduce the growth of microorganisms. However, this finding contradicts those of Sucipto et al. (2020) where sanitation facilities were not adequate. Careful and frequent hand washing coupled with clean equipment, environment, and personnel are necessary to maintain a sanitary environment for milk processing. Personnel hygiene (handwashing, uniforms) as well as Good Manufacturing Practices (GMPs) are important in combating hygiene problems in these processors [18]. It is also important that location and the sanitizing stations are maintained to ensure good hygiene practices

All the processors obtained water from the municipal council while others (50%) supplemented with water from the boreholes. It was noted that water used was portable and was tested for microbial quality in the laboratory. On a positive note, results of water testing in the last six months had not been found to be contaminated with any microbial contaminant. Analysis was mainly done on coliforms, TVC and on yeast and molds. These findings contrast to those of Sucipto et al. (2020) where periodical was not practiced and according to Cabral [19] water quality for food processing should be done at least twice per year. According to Canadian Food Agency it is important that water is safe and adequately supplied in processing applications. If the source of water poses contamination risk like the borehole water, it is necessary to treat the water.

All milk processors had a system to control cross contamination and was enforced through means such as the use of different colour codes, memos and notices and through colour coding of processing equipment. The measure taken to prevent cross contamination were also highlighted by Food Standards Agency. According to FSA, other measures include effective cleaning and disinfection procedures, personal hygiene particularly hand washing and effective management controls and training. Colour coding is primarily an effective measure in controlling cross contamination and become one of the preventive controls to protect food against direct contamination, cross-contact, and cross-contamination incidences. A color-coding plan stipulates the colors for handling different milk products within a processing plant and therefore reduces the risk of cross contamination. According to WHO (2002) and Merwan et al. [9] by practicing hygiene before handling milk and ensuring the cleanness of all equipment and surfaces, cross contamination can prevent cross contamination. It was also noted that movement restrictions were imposed on personnel and equipment within the facility in all the premises surveyed. All the premises surveyed had a separate area for handling raw milk and pasteurized products, used disposable food grade gloves in handling open foods and installed designated hand washing areas.

The initial diagnosis of the milk processing plants on the implementation of GMP indicated an average of 78% of conformity. Among the areas that were assessed, licensing and hygiene depicted the highest percentages of conformity. These results show better conformity levels in the areas assessed compared to Costa-Dias et al. (2012) working on GM implementation in cheese factory. The authors reported an average of 32% conformity. In their work they reported high non-conformity in personal hygiene something that was found to be handled well in the current study. However, having non-conformity in areas such as process control,

microbial contamination and milk safety may pose great risks to food safety and corrective measures must be taken to improve the level of processing plants regarding implementation of GMP.

5. CONCLUSION

Together with analysis of the factors that can influence the implementation of these systems. The present study has demonstrated that the implementation of GMP practices was above average. However, with detection of contamination pathogens continuous improvement in GMP practices will ensure food safety. This study has shown that the milk processors have implemented the necessary systems capable of ensuring safe products are delivered to the final consumer, the employees in charge of and spearheading the food safety controls and fully qualified on the requirements and the staff are adequately trained to be able to understand what is required of them in terms of GMPs.

6. RECOMMENDATIONS

The regulators should encourage and emphasize on the analysis of the other food pathogens such as the *Staphylococcus aureus* and *Listeria monocytogenes* that are not routinely done by most of the processors. Additional efforts should be put in place to enhance controls of *E.coli* contamination.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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