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Microbial Contamination Associated with "Wagashi-Cheese" Production in Sissala East District- Ghana

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Abstract

The purpose of the study was to identify the possible sources of microbial contamination in the production of W*agashi-Cheese* in the Sissala East District, Upper West Region of Ghana. Also, the hygienic practices involved were examined. A survey, observation and experiment were used to collect data. Eighty (40 raw cow milk producers and 40 W*agashi-Cheese* producers) were randomly selected for the survey. Six (3 milk producers and 3 W*agashi –Cheese* producers) were purposively sampled for the experimental part. Microbial analysis of the milk and Wagashi-Cheese were carried out using the ISO and NMKL Analytical Standard procedures. Findings from the study revealed that milk and W*agashi-Cheese* producers do not practice optimal personal, food and environmental hygiene. Coliform, fecal coliform, *Escherichia coli*, Total mesophilic (PCA), yeast and mould were identified in both the milk and W*agashi-Cheese*. Dirty cow teat, unclean containers for receiving milk and improper handling of milk while transporting to Wagashi-Cheese centers were identified as Critical Control Points along the production line of W*agash-Cheese*. Post interventions showed significant ($p \leq 0.05$) reduction in microbial levels in the samples analyzed. In conclusion, the application of Hazard Analysis Critical Control Point (HACCP) improved the quality of the final product. HACCP education and training for milk and W*agashi-Cheese* producers is highly recommended. In conclusion, there is a significant difference ($P \geq 0.05$) in the microbial load of wagashi from the selected producers and thus the alternate hypothesis that there is no significant difference in the microbial loads of wagashi from different producers.

Keywords: contamination, microbes, hygiene, Wagashi-Cheese, Ghana

1. Introduction

Milk is one of the most nutritionally complete foods that is directly available for consumption and adds high quality protein, fat, lactose, essential minerals and vitamins to diet (Grimoud, Serunjogi, Grillet, Kato, & Faye, 2009; Foskett & Paskins 2011). Hempen, Unger, Munstermann, Seck and Niamy (2004) reported that the biological value of milk is second to eggs in regards to essential amino acids, energy, calcium and vitamins making it a complete diet. Foskett and Paskins (2011) noted that milk makes a valuable contribution to daily human diet helping individuals to meet their nutritional needs. Milk though healthy for human nutrition, present favorable conditions that promote microbial growth (Leus, deBeer, Jacoby, Jansen, & Shale, 2010). Clarence (as cited in Ibrahim, Falegan, & Olalumade, 2014) also described milk as food designated by nature for both the young and adults, and wholesome milk should contain only a few bacteria with no extraneous matter, if it has been produced under hygienic conditions. Handling of milk during and after milking may change its natural composition and physiochemical properties (Kurwijila, 2006; Mirkena, 2010). Produced traditionally from cattle raised by local farmers, milking is often exposed to flies and other insects. Also, unpasteurized milk is usually transported on foot, bicycles and donkey carts to sale centers in Sissala through the hot sun. Ladles and plastic bowls are used to fetch milk anytime and sold to customers

Milk can be consumed as raw or processed with the raw one being the major source for most households in the northern, upper east and west regions of Ghana. It is often served with breakfast or snack dishes like *kooko, gari, maasa, foura, basi,* and *kpakyerama*. It is also used in preparing cheese called *wagasji* in the local dialect and the most popular milk product consumed in the Upper West region. It is soft cheese often processed from surplus and left over milk which could not be bought in the market. *Calotropis procera* vegetable extract is used

to coagulate milk into *wagashi* during production. Cheese made from fermented fresh milk is one of the most highly concentrated nutritious dairy product commonly made in Europe and North America *Wagashi* can be eaten as snack and is used in preparing soups and stews. It's an excellent source of fat, calories, protein, vitamin A and C as well as minerals such as calcium and phosphorus (Foskett & Paskins, 2011).

Micro-organisms are found everywhere and are likely to be introduced into the *wagashi* through the various stages of production such as milking, processing, storage, transportation, distribution and consumption. *Escherichia coli*, *Listeria monocytogenes*, *Staphylococcus aureus, Campylobacter jejuni* and *Bacillus* cereus have been isolated from *wagashi* at high above acceptable limits of food standards (Omore et al., 2009). To produce wagashi which is safe for human consumption, it is important to determine probable sources of contamination along the production line. Although there have not been any documented reports of diseases directly associated with wagashi consumption, the unhygienic conditions under which they are produced raise several concerns. The study thus examined the sources of microbial contamination in the production of wagashi from milking to distribution of the final product applying the HACCP principles. Hygienic practices were introduced as an intervention and the related effects on the safety of the products were assessed.

1.1 Objectives

1. To identify the main sources of microbial contamination at the milking stage;
2. To ascertain practices likely to introduce micro-organisms into *Wagashi* during production;
3. To assess the impacts of adopted interventions on the microbial contamination of *Wagashi*.

1.2 Research Hypothesis

HO: There is no significant difference in the microbial load of *Wagashi* from selected producers.

HA: There is a significant difference in the microbial load of *Wagashi* from selected producers.

2. Methodology

2.1 Research Design

The study was conducted in the Sissala East District located in the north-eastern part of Upper West Region of Ghana. The mixed methods approach was used. This included a survey, observation and experiment design. The survey design and observation were used to gather data on the demographic and hygienic practices of selected milk and *wagashi* producers. The experiment was carried out to determine the microbial contamination along the production line of *wagashi* from milking to fried *wagashi*. The experiment was conducted to test the effect of change in the production process (independent variable). The effect of other strenuous variables such as temperature, time, and contamination from laboratory tools and equipment which could influence the degree of change in dependent variables as the independent variable changed.

The Hazard Analysis Critical Control Point (HACCP) was used to identify probable microbial hazards and the respective critical control points of these identified microbial hazards. As an intervention, milk and *wagashi* producers were taken through some preventative control measures. The control measures were used to modify some practices at the identified critical control points along the wagashi production chain as a way to assess the impact of these measures on microbial loads.

2.2 Sample and Sampling Procedure

The simple random sampling was used to select a sample of 80 (40 cow milk and 40 *wagashi* producers) out of a total of 120 producers (specifically 68 milk and 52 *wagashi* producers) for the survey. Fraenkel, Wallen and Hyun (2012) reported that for a population of 120, a total of 80 was deemed a good representative sample size. Subsequently, purposive sampling was used to select 6 (3 milk and 3 *wagashi* producers) for the experimental aspect of the study. The 6 producers were grouped into 3 specifically A, B, and C for determining the microbial level along the *wagashi* production chain.

2.3 Population

The population for the study consisted of all cow milk and *wagashi* producers in the Sissala East District who together totaled 120 in number. The initial counting was done at the Fulani chief house where prior arrangement was made for him to invite all the producers from Tumu town and the surrounding communities for a preliminary discussion on the study. The counting was done community by community with 46 producers being present at the meeting. The producers present helped with identifying the rest of the population which comprised of 68 milk producers and 52 *wagashi* producers.

2.4 Microbial Analysis of Milk and Wagashi Samples

A total of 60 samples were collected from milk and *wagashi* producers for the microbial analysis. The first 30 samples collected were used for a pretest laboratory analysis. Results from this analysis helped determine the microbial hazards and their respective critical control points along the *wagashi* production chain i.e. from milking of the cows to distribution of the final product. After this initial testing, possible control measures were implemented and followed by the collection of another set of 30 samples for the post-test microbial analysis. Swabs from the: udder/teat of the cows; equipment used in storing milk and processing wagashi and personnel's hands were taken. Also milk: from the milking point and that received after milking. Processed sodom apple plant stems (coagulant); mixture of milk and coagulant; heated milk/ set curd; and pressed curd /fresh *wagashi* and processed curd/ fried *wagashi*

Six samples each of the above listed items were aseptically collected into sterile bottles, bags and dilution tubes from all the selected producers. Each specimen was labeled using the letters of the production chain and the sample serial number thus A_1- $A_{10,}$ B_1- B_{10} and C_1-C_{10} for *wagashi* production before intervention whereas the post-test samples were coded EA_1- $EA_{10,}$ EB_1- EB_{10} and CC_1-CC_{10} for *wagashi* production after intervention. The entire labeled samples were placed in an ice chest with lots of ice and transported immediately to the Food Research Institute laboratory, Accra for immediate culturing within 24hours as described by NMKL (2004) and ICMS (1998).

2.5 Data Collection Procedures

Two different sets of interview schedules were administered to selected milk and *wagashi* producers and an observation checklist was used for observation. The interview guide had both open and closed ended questions, and the observation checklist were adapted from Nyamari (2013), Dailey (2011) and Campbell (2011) who conducted similar studies using hospital food handlers, milk farmers and street food vendors respectively. Respondents' consents were orally sort prior to conducting interviews as well as confidentiality of responses and animosity of respondents. Interviews were done on one on one basis in the respondents' homes or work places at their own convenience. Observations were made at the milking centers (kraals) and *wagashi* production centers (homes/shops) in the morning between 8:30am and 10:30am when milking was done and between 11:30am and 1:30pm during wagashi production**.**

Wagashi samples prior to intervention were collected from selected producers, analyzed and used to identify the Critical Control Points (CCPs) along the production chain. Samples collected were prepared through homogenization and serial dilutions. For homogenization, 10g of each sample was aseptically weighed into 90mls of sterile salt peptone solution (SPS) which contained 0.1 % peptone and 0.8 % sodium chloride with pH adjusted to 7.2. Homogenization was done using the Stomacher (mode l 4001, Seward Medical) for 30 seconds at normal speed. This provided 10-1 dilution. This was vortexed for about 2 minutes to ensure uniform mixing. A sterile pipette was used to take 1 ml of the 10^{-1} dilution into 9mls of sterile salt peptone water to obtain 10^{-2} dilution. This procedure was repeated for 10^{-3}, 10^{-4}, 10^{-5}, and 10^{-6} dilutions. Further, from appropriate tenfold serial dilution, 1 ml aliquot of each dilution (10^{-1}, 10^{-2}, 10-$^{-3}$, 10^{-4}, 10^{-5} and 10^{-6}) was inoculated into sterile Petri dishes and the appropriate media added for enumeration and isolation.

The total coliform, fecal coliform, *Escherichia coli*, S*taphylococcus aureus, Salmonella species*, yeast and molds were identified using the ISO and NMKL Analytical Standard procedures. The laboratory was fumigated with methylated spirit, allowed to air dry and closed for 15 minutes. Floors and walls of the inoculation room were also sterilised with disinfectant solution. All Petri dishes and pipettes were sterilized by autoclaving and left to cool at ambient temperature before use. Ethanol was used to clean all work surfaces and some instruments used like the scissors. Forceps and loops were flame-sterilized (using a Bunsen burner flame) before every use. Gloves and clean laboratory coats were worn throughout the process. After appropriate incubation, plates with 30–300 colonies were selected and counted. The number of colony-forming units per g (cfu/g) of each sample was calculated by multiplying the number of bacteria by the dilution. Every analysis was done in duplicate to ensure reliability of results. The specific microbial tests conducted were:

i. Enumeration of Aerobic Mesophiles (viable plate count): Aerobic mesophiles were cultured using the pour plate method (Balows et al., 1991) and plate count agar medium (OXOID CM 325). The plates were incubated at 30 °C for 72 hours (NMKL no. 86, 2006).

ii. Enumeration and Isolation of Total Coliform: Coliform bacteria were cultured using the pour plate method and Tryptone Soya Agar medium (OXOID CM131). The pH was adjusted to 7.3 and overlaid with Violet Red Bile agar (OXOID CM 107) with pH adjusted to 7.4, and incubated at 37 °C for 24 hours. Colonies were

confirmed using Brilliant Green Bile broth (OXOID CM 31) at pH of 7.4 and incubated at 37 °C for 24 hours (NMKL no.44, 2004).

*iii. Enumeration of Escherichia coli***:** *Escherichia coli* bacteria were cultured using the pour plate method and Trypsin Soya agar medium (OXOID CM131) adjusted to pH 7.3 and overlaid with Violet Red Bile agar (OXOID CM 107) with pH adjusted to 7.4, and incubated at 44 °C for 24 hours. Colonies were confirmed using E.C. broth (OXOID CM 853) with pH adjusted to 6.9. Colonies that produced gas were confirmed for Indole production. This was done by sub- culturing into Tryptone water and incubated at 44 °C for 24 hours. Indole test was done by putting a drop of Convac reagent into the culture. Red ring coloration at the surface of the Tryptone indicated Indole positive (NMLK no.125, 2005).

*iv. Biochemical confirmation***:** Five typical and suspected colonies of *Escherichia coli* were sub cultured each in tubes of *Escherichia coli* broth containing inverted Durham tubes. It was incubated at 44°C for 24 hours. Positive tubes turned cloudy and trapped gas as a result of the lactose fermented by the suspected *Escherichia coli*. About 0.1ml of the broth was sub cultured in tryptone broth and incubated at 44°C for 24 hours. About 2 to 3 drops of Kovac's reagent was added to each of the tubes and left to stand for about 10 seconds. Appearance of a violet or pinkish ring like structure on top of the broth indicated the presence of *Escherichia coli* in the sample. It was then recorded as number of positive tubes / total number of tubes (5).

v. Enumeration of Yeast and Moulds: Yeasts and moulds were enumerated by the pour plate method on Dichloran Rose Bengal Chloramphinicol (DRBC) medium, (Oxoid CM0727; Oxoid Ltd., Basingstoke, Hampshire, UK) to which 1% Chloramphinicol in absolute ethanol was added as supplement to suppress bacteria growth. The pH was adjusted to 5.6 and incubated at 25°C for 3-5 days in accordance with ISO 7954 (1987).

*vi. Enumeration of Staphylococcus aureus***:** Enumeration of *Staphylococcus* was done by the spread method using Baird- Parker agar (OXOID CM 275). About 0.1 ml of the aliquot was inoculated onto the surface of Baird- Parker agar. A sterile glass rod was used to spread the medium onto the surface of the Baird Parker medium. The plates were incubated at 37°C for 48 hours. Colonies were confirmed for coagulate positive using Rabbit Plasma Serum. Coagulation of the serum indicated coagulate positive (confirmation test for *Staphylococcus aureus).*

vii. Detection of Salmonella species: Approximately 25g of each sample was weighed aseptically into sterile Stomacher bag and 225ml buffered peptone water added. This was homogenized thoroughly and incubated at 37 °C for 16-21 hours. Following incubation, 0.1ml of broth (buffered peptone water) was transferred into 10ml of Rappaport-Vasilliadis (RVS) broth and incubated in water bath at 42°C ± 0.5°C for 24 ± 3h. Following enrichment, a loop full of Rappaport-Vasilliadis (RVS) broth culture was streaked onto XLD Agar plates, and the plates were incubated at 37°C ± 0.5°C for 24h ± 3h. Presumptive colonies (lightly transparent zone of reddish color and black center) were maintained on non-selective TSA agar slants for further biochemical tests.

*viii. Biochemical confirmation***:** Suspected colonies were confirmed on Triple Sugar Iron medium, Urea Agar Base (UAB) medium and Lysine Decarboxylase Broth medium and incubated at 37 °C for 24 hours. For Serological confirmation, suspected colonies were streaked onto Tryptone Soya Agar medium and incubated at 37 °C for 24 hours. A colony was picked and put onto a clean slide. One drop of anti-serum O was added to the colony on the slide. A clean cover slip was used to mix the colony and the anti-sera. Clotting/ agglutination indicated presence of Salmonella.

*ix. Triple Sugar Iron Confirmatory (TSI) Test***:** Using aseptic techniques, a colony of the test organism was picked with a sterile inoculating loop, and the slant of the media streaked. Using a sterile inoculating needle, the butt of the medial was then stabbed. Tubes were then inoculated at 37°C for 24 hours after which they were observed. A yellow butt and a red slant indicated fermentation of lactose/ or sucrose. Blackening of agar indicated the production of H_2S gas. A red butt and a slant indicated that none of the sugars were fermented and neither gas nor H_2S were produced. Blackening and gas formation in TSI tube indicated presence of *Salmonella*.

2.6 Intervention

After the first microbial analysis, HACCP were implemented to reduce contamination along the production chain and a second microbial analysis was done to assess the intervention effect on production. The experimental group were trained for 2 weeks on how to apply HACCP to help minimize microbial loads along the *wagsashi* production chain.

Measures adopted included good hand washing with soap and warm water; washing of cow's udder and teat with warm water and soap; cleaning and sterilization of equipment used for milking and *wagashi* preparation

with hot water. The milk and *wagashi* producers were also encouraged to bath, dress in clean clothes, cover their hair and wear hand gloves. Producers were provided with soap and hand gloves, and were assisted with the activities and supervised.

2.7 Data Analysis

Data obtained from the survey was input in excel, analyzed using descriptive statistics and presented as percentages and frequencies. A $\log_{10}$ transformation of bacterial count was done and means presented in tables. The mean microbial counts after the intervention were compared with those of the pre-intervention using descriptive statistics. The significant differences between means were calculated by Analysis of Variance at $p \leq 0.05$.

3. Results

Table 1. Demographic characteristics of milk and wagsashi producers

Variable	Milk		Wagsashi	
	Frequency	**Percentage (%)**	**Frequency**	**Percentage (%)**
Sex				
Male	1	2.6	0	0
Female	38	97.4	40	100
Age:				
Less than 20	11	27.5	8	20
21 – 30	20	50.0	18	45
31 – 40	7	17.5	12	30
41 – 50	2			5.0
Above 50	-	-	-	-
Educational Status:				
No formal education	39	97.5	33	82.5
Primary	1	2.5	3	7.5
JHS	0	0	1	2.5
SHS	0	0	3	7.5
Technical/Vocational	-	-	-	-
Tertiary	-	-	-	-

Findings from Table 1 show that the milk and wagsashi producers were mostly females (97.4%) and the industry can be said to be gender biased. These females seem to start the vocation early on in life with 77.5% falling between the ages of 21 and 40 years old (Table 1). It is possible that these women started some years earlier although they were not asked how many years they have been engaged in this vocation. Considering the fact that there were no women above the age of 50 years, it will be interesting to find out whether these women give up this vocation as they age or is it because of other reasons. Almost all the women had no formal education (97.5%) as shown in Table 1.

Table 2. Food hygiene practices of milk producers

Practices	**Yes**	**No**	**Total**
	*Number **%	*Number **%	*Number **%
Use antibiotics to treat cows	*39 **97.5	*1 **2.5	*40 **100
Conduct routine vaccination regularly	*39 **97.5	*1 **2.5	*40 **100
Conduct test/surveillance for diseases	*36 **89.7	*4 **10.3	*40 **100
Check cows for diseases on regular basis	*34 **85.0	*6 **15.0	*40 **100
Use drinkable water for cleaning purpose	*33 **82.5	*7 **17.5	*40 **100
Keep records of vaccinations	*33 **82.5	*7 **17.5	*40 **100
Conduct check for mastitis	*25 **62.5	*15 **37.5	*40 **100
Cows had mastitis in the last six months	*18 **45.0	*22 **55.0	*40 **100
Wash hands with warm water and soap	*10 **25.0	*30 **75.0	*40 **100
Clean cow udder with warm water before milking	*5 **12.5	*35 **87.5	*40 **100
Clean cow udder with warm water after milking	*4/ **0.0	*36 **90.0	*40 **100
There is association for milk producers	*3 **7.5	*37 **92.5	*40 **100
Disinfect milk collection containers	*2 **5.0	*38 **95.0	*40 **100
A member of milk producers association	*2 **5.0	*38 **95.0	*40 **100
Have health certificate on the work issued	*2 **5.0	*38 **95.0	*40 **100
Have education for milk producers	*1 **2.5	*39 **97.5	*40 **100

*Frequencies ** Percentages

Unpublished data from this study

Findings show that several of the practices the respondents stated they engaged in do help with reducing microbial load Table 2. The use of antibiotics to treat infections in the cows and the routine vaccination would all promote health in the cows leading them to produce healthy milk. Slightly more producers used antibiotics (97.5%) than engaged in routine vaccination (89.7%) and regular checks on the health of the cows (85%). The health checks included checks for mastitis (65%) which proved that 45% of the animals had mastitis in the past 6 months prior to the study and 37.5% of the producers did not check their animals for the disease. Contrary, there were practices that increased the risk of contamination. This included non use of disinfectants in cleaning milk collecting equipment and lack of health certificates to prove that producers are healthy (95%) to carry out production in Table 2. Udders of cows were not properly cleaned with warm water prior to milking (87.5%) coupled with use of unwashed hands (75%) for milking as shown in Table 2. With the application of HACCP, the risk at hazard critical points such as the teats of cows and equipment for collecting milk among others will be reduced to improve safety of the milk.

Table 3. Food hygiene practices of w*agashi* producers

Practice	**Yes**	**No**	**Total**
	*Number **%	*Number **%	*Number**%
Sell the finished product immediately	*30 **75.0	*10 **25.0	*40 **100
Wash hands regularly during *wagashi*	*29 **72.5	*11 **27.5	*40 **100
Have leftovers after marketing	*29 **72.5	*11 **27.5	*40 **100
Throw waste water outside on the ground	*24 **60.0	*16 **40	*40**100
Use stainless steel containers for *wagashi*	*13 **32.5	*27 **67.5	*40 **100
Store the leftovers in refrigerator	*12 **30.0	*28 **70	*40 **100
Clean equipment with warm water and soap	*8 **20.0	*32 **80	*40**100

after the preparation of *wagashi*			
Clean the equipment with warm water and soap before the *wagashi* preparation	*7 **17.5	*33 **82.5	*40 **100
Throw kitchen garbage in a bin	*5 **12.5	*35 **87.5	*40 **100
Have health certificate to work	*2 **5.0	*38 **95.0	*40 **100
Form association for *wagashi* producers	*0 **0.0	*40 **100	*40 **100
A member of association	*0 **0.0	*40 **100	*40 **100
Have educational programs for members	*0 **0.0	*40 **100	*40**100
Are these programs regular	*0 **0.0	*40 **100	*40 **100

*Frequencies ** Percentages

Unpublished data from this study

Findings showed that 80% of the wagashi producers did not store the left over products after sale in the refrigerator Table 3 although majority (75%) sold their products immediately after production. Approximately the same percent of producers 82.5% and 80% respectively did not wash the equipment used for production with soap and warm water prior and post production Table 3. All producers were ignorant of any probable association for wagashi producers and so none of them joined any association and surprisingly 95% did not have any health certificates as proof for being healthy enough to produce wagashi for sale to the public Table 3. Lack of educational programs to help educate producers to promote food safety is unfortunate. Keeping milk and cheese at the right temperature is very important to ensure safety of the milk and cheese and the fact that the producers were not doing that often pose a food safety risk with the consumption of milk and cheese from such sources.

Table 4. Personal hygiene practices of milk producers

	Yes	**No**	**Total**
Observations	*Number **%	*Number **%	*Number **%
Milk kept sealed	*39 **97.5	*1 **2.5	*40 **100
Jewellery worn at time of visit	*29 **72.5	*11 **27.5	*40 **100
Handlers' nails were clean	*18 **45.0	*22 **55.0	*40 **100
Wear clothes clean	*12 **30.0	*28 **70.0	*40 **100
Have discharge from nose during visit	*4 **10.0	*36 **90.0	*40 **100
Visible wound has been plastered	*3 **7.5	*37 **92.5	*40 **100
Have visible wound at time of visit	*1 **2.5	*39**97.5	*40 **100
Milk handlers wear protective clothes	*0 **0	*40 **100.0	*40 **100

*Frequencies ** Percentages.

Unpublished data from this study.

Almost all producers observed (87.5%) kept their milk sealed to prevent insects and dust from entering it Table 4. Less than half of the producers (45%) had their finger nails short and clean with only 30% wearing clean clothes Table 4. The practice of wearing jewelry (bangles and rings) was prevalent among producers (72.5%). None of the producers observed wore protective clothing. Observation of personal hygiene was below standard.

Table 5. Personal hygiene practices of w*agashi* producers

Observations	**Yes** *Number **%	**No** *Number **%	**Total** *Number **%
Wear jewellery during production	*28 **70.0	*12 **30.0	*40 **100*
Handlers' nails clean	*26 **65.0	*14 **35.0	*40 **100
Wear clothes clean clothes	*24 **60.0	*16 **40.0	*40 **100
Cooked product kept in a sealed condition	*24 **60.0	*16 **40.0	*40 **100
Have discharge from nose	*5 **12.5	*35 **87.5	*40 **100
Wear protective clothes	*3 **7.5	*37 **92.5	*40 **100
Have visible wound at time of visit	*0 **0.0	*40 **100.0	*40 **100

*Frequencies ** Percentages.
Unpublished data from this study.

Fewer producers (70%) in the case of wagashi wore jewelry Table 5 than the milk producers 72.5% in Table 4. Also 65% wagashi producers kept their nails short and clean at the time of visit and 60%) wore clean clothes. Final products were stored in sealed containers. Producers looked healthy without any discharge coming from their noses (87.5%) nor open wounds on their bodies Table 5.

Table 6. Milking practices observed during study

Observations	**Yes** *Number **%	**No** *Number **%	**Total** *Number **%
Conduct milking at regular intervals daily	*39 **97.5	*1 **2.5	*40 **100
Clean milking equipment before milking	*35 **87.5	*5 **12.5	*40 **100
Discard the fore milk	*6 **15.0	*34 **85.0	*40 **100
Wash the udder before milking	*5 **12.5	*35 **87.5	*40 **100
Dry the udder with clean towels	*4 **10.0	*36 **90.0	*40 **100
Remove the fore milk into separate container	*4 **10.0	*36 **90.0	*40 **100

*Frequencies ** Percentages.
Unpublished data from this study.

It is worth noting that 87.5% of the producers kept milking equipment clean. However, 90% of the producers did not separate the fore milk from the main milking nor washed the udders of the cows prior to milking (87%).

Table 7. Raw material management practices of w*agashi p*roducers

Practice	**Yes** *Number **%	**No** *Number **%	**Total** *Number **%
Have standards for milk used for *wagashi*	*39 **97.5	*1 **2.5	*40 **100*
Clean the bulk container regularly	*39 **97.5	*2 **2.5	*40 **100
Obtain milk fresh from the kraal	*38 **95	*2 **5.0	*40 **100*
Use drinkable water for cleaning purpose	*38 **95.0	*2 **5.0	*40 **100
Have quality checks for *wagashi* production	*5 **12.5	*4 **85.0	*40 **100
Transport the milk in a vehicle	* 1 **2.5	*39 **97.5	*40 **100
Quality checks conducted regularly	* 1 **2.5	*39 **97.5	*40 **100
Milk stored in a refrigerator before use	*0 **0.0	*40 **100	*40 **100

*Frequencies ** Percentages.
Unpublished data from this study.

Milk consistency and temperature were some of the standards wagashi producers followed (97.5%). All these producers also stated that they cleaned and sterilized the bulk containers used for storing milk for *wagashi* production regularly. A few less (95%) (Table 7 reported obtaining milk straight from the kraal and used clean drinkable water for cleaning purposes. Transporting milk for several minutes (≥ 30 minutes) on foot to wagashi centers as well as regular absence of quality checks were reported by 97% producers *Table 7. Out of this percentage, 85% of them were ignorant of quality checks that may be available for wagashi production. It was disturbing to learn that all the w*agashi* producers sampled reported not storing milk in refrigerators prior to use with excuses that they did not own refrigerators and if they did, the high cost of electricity may still not make it affordable for the producers

For producer A, milk from milking point, heated milk curd and Fried *wagashi* had no faecal coliforms, ***Escherichia coli or Staphylococcus aureus*** but these were present in all the other samples. The heated and fried products did have moulds but not yeast. *Salmonella* was absent in all samples Table 8. Heat seemed to be the cause of destruction of these microorganisms. PCA/TVC were counted in all samples. Similar results were obtained for producer B where PCA/TVC were counted in all samples but there was no *Salmonella* detected in any of the samples. Samples from producer B seems to be safer with no *Escherichia coli* in samples taken from the milk point and at the point where the milk was received (Table 9). Samples taken from producer C seems to have similar characteristics as that taken from producer B with no *Escherichia coli i*n samples taken from the point of milking and point of receiving milk (Table 10). Comparing the microbial loads of the samples taken before the intervention Table 8-Producer A) and that taken after the intervention Table 11-Producer A, absence of *Escherichia coli*, faecal coliforms and *Staphylococcus aureus* is an indication that the HACCP measures put in place were effective in controlling these microorganisms and making the food safer. Similarly, these same organisms were absent in samples taken from producer B and C Table 12 & 13. Among the 3 producers, B in Table 12 seemed to have the best results after the intervention with the absence of an additional organism, mould and surprisingly yeasts were found in samples taken from sample A and C after the intervention even though these were absent in the pre-intervention samples. There were no moulds in all the samples collected and analysed from producer C in Table 13.

Table 8. Mean microbial counts (cfu/ml/cfu/g) for Processor 'A' during the processing of w*agashi* before intervention

Sample	Coliforms	*Escherichia coli*	Feacal coliforms	*Staphylococcus aureus*	PCA/TVC	Yeasts	Moulds	*Salmonella*
Swabs from cows udder and teat A1	(7.80±2.1) 10^4	(7.10±3.8) 10^2	(1.45±3.5) 10^3	(3.45±3.0) 10^2	(8.15±1.6) 10^6	(1.50±2.8) 10^3	(1.95±7.7) 10^2	Not Detected
Swabs from production equipment A2	(3.31±1.7) 10^5	(1.65±7.8) 10^2	(2.01±2.7) 10^3	(2.00±1.6) 10^2	(1.11±4.4) 10^6	(1.45±3.4) 10^2	(7.00±2.8) 10^1	Not Detected
Swabs from personal hands A3	(2.30±1.4) 10^5	(3.75±1.1) 10^2	(4.75±5.0) 10^3	(4.20±2.8) 10^2	(2.08±1.9) 10^6	(4.45±1.1) 10^3	(1.35±3.5) 10^2	Not Detected
Milk from milking point A4	(2.50±0.7) 10^1	0.00	0.00	0.00	(3.50±3.5) 10^3	0.00	(5.00±7.1) 10^1	Not Detected
Received milk A5	(4.30±1.4) 10^2	(7.00±2.8) 10^1	(2.15±3.1) 10^2	0.00	(8.40±1.1) 10^3	(5.00±2.8) 10^1	(7.00±9.9) 10^1	Not Detected
Coagulant A6	(2.90±1.9) 10^3	0.00	(2.00±0.0) 10^2	0.00	(3.37±2.8) 10^3	(6.00±1.4) 10^2	(2.20±2.8) 10^2	Not Detected
Mixture of milk and coagulant A7	(1.95±0.2) 10^3	0.00	(2.70±2.1) 10^2	0.00	(1.45±6.4) 10^3	(5.05±7.8) 10^3	(4.40±9.5) 10^2	Not Detected
Heated milk curd A8	0.00	0.00	0.00	0.00	(7.80±1.7) 10^2	0.00	0.00	Not Detected
Fresh *wagashi* A9	(8.50±0.7) 10^2	0.00	(2.5±0.00) 10^2	0.00	(3.75±1.1) 10^2	0.00	0.00	Not Detected
Fried *wagashi* A10	0.00	0.00	0.00	0.00	(1.60±1.1) 10^2	0.00	0.00	Not Detected

Unpublished Laboratory Results from this study.

Table 9. Mean microbial counts (cfu/ml, cfu/g) for Processor 'B' during the processing of w*agashi* before intervention

Samples	Coliforms	*E.coli*	Feacal coliforms	*Staph. aureus*	PCA/TVC	Yeasts	Moulds	Salmonella
Swabs from cows udder and teat B1	(5.75±2.1) 10^5	(2.60±5.7) 10^2	(4.55±1.6) 10^3	(1.49±8.7) 10^3	(4.05±4.6) 10^7	(2.60±8.5) 10^2	(7.00±2.8) 10^1	Not Detected
Swabs from production equipment B2	(2.05±1.6) 10^5	0.00	(4.25±3.2) 10^3	(3.10±4.1) 10^2	(8.55±4.9) 10^6	(6.00±5.7) 10^1	(5.30±5.2) 10^2	Not Detected
Swabs from personal hands B3	(3.25±4.6) 10^5	(5.50±2.1) 10^1	(6.10±1.6) 10^3	(2.50±7.7) 10^2	(4.74±5.6) 10^7	(6.00±7.1) 10^2	(1.20±5.7) 10^2	Not Detected
Milk from milking point B4	(2.20±3.1) 10^2	0.00	0.00	0.00	(6.00±8.4) 10^2	(5.50±4.2) 10^2	(6.00±4.2) 10^1	Not Detected
Received milk B5	(1.65±9.2) 10^3	0.00	(3.00±2.8) 10^1	0.00	(2.70±8.5) 10^3	(7.50±4.2) 10^1	(2.55±2.1) 10^2	Not Detected
Coagulant B6	(3.95±1.2) 10^3	(2.50±7.1) 10^1	(2.25±1.1) 10^3	(1.50±7.1) 10^1	(9.65±1.6) 10^3	(2.90±1.7) 10^2	(3.40±2.3) 10^2	Not Detected
Mixture of milk and coagulant B7	(4.65±5.0) 10^3	0.00	(2.05±3.3) 10^2	0.00	(1.20±0.9) 10^4	(1.92±2.3) 10^2	(6.80±2.8) 10^2	Not Detected
Heated milk curd B8	0.00	0.00	0.00	0.00	(9.60±3.4) 10^2	0.00	0.00	Not Detected
Fresh *wagashi* B9	0.00	0.00	0.00	0.00	(2.52±1.1) 10^4	0.00	0.00	Not Detected
Fried *wagashi* B10	0.00	0.00	0.00	0.00	(1.35±1.1)10^2	0.00	0.00	Not Detected

Unpublished Laboratory Results from this study

Table 10. Mean microbial counts (cfu/ml, cfu/g) for Processor "C' during the processing of w*agashi* before intervention

Sample	Coliforms	*Escherichia coli*	Faecal coliforms	*Staphylococcus. Aureus*	PCA/TVC	Yeasts	Moulds	Salmonella
Swabs from cows udder and teat C1	(8.33±2.1) 10^4	(8.50±3.5) 10^1	(4.15±1.3) 10^3	(3.90±2.4) 10^2	(5.00±9.9) 10^6	(3.25±1.5) 10^4	(9.30±8.1) 10^2	Not Detected
Swabs from production equipment C2	(5.29±5.1) 10^4	0.00	(4.30±2.0) 10^3	(1.15±3.5) 10^2	(7.46±9.4) 10^7	(9.00±2.8) 10^1	(1.30±1.4) 10^3	Not Detected
Swabs from personal hands C3	(3.31±4.5) 10^5	(6.50±3.5) 10^1	(3.36±4.2) 10^3	(4.75±1.2) 10^2	(2.70±1.7) 10^7	(5.30±1.7) 10^3	(5.15±5.4) 10^2	Not Detected
Milk from milking point C4	(2.65±2.5) 10^1	0.00	(4.50±4.2) 10^3	0.00	(4.90±3.3) 10^3	(5.00±7.1) 10^1	(1.00±1.4) 10^1	Not Detected
Received milk C5	(2.35±1.5) 10^1	0.00	0.00	0.00	(4.20±1.4) 10^3	(1.40±8.5) 10^3	(2.60±1.9) 10^2	Not Detected
Coagulant C6	(7.05±5.6) 10^3	0.00	(1.30±7.1) 10^3	0.00	(2.00±1.6) 10^4	(2.60±2.1) 10^2	(4.05±1.3) 10^2	Not Detected
Mixture of milk and coagulant C7	(4.47±3.6) 10^4	0.00	(2.75±2.2) 10^3	(3.00±1.4) 10^1	(5.01±6.8) 10^3	(1.00±1.4) 10^1	(4.35±9.2) 10^2	Not Detected
Heated milk curd C8	0.00	0.00	0.00	0.00	(1.82±2.1) 10^3	0.00	0.00	Not Detected
Fresh *wagashi* C9	(1.25±1.1) 10^1	0.00	0.00	0.00	(6.50±2.7) 10^4	0.00	0.00	Not Detected
Fried *wagashi* C10	0.00	0.00	0.00	0.00	(1.75±9.2) 10^2	0.00	(1.50±7.1) 10^1	Not Detected

Unpublished Laboratory Results from this study.

Table 11. Mean Microbial Counts (cfu/ml or cfu/g) for Processor 'A' during the Processing of *Wagashi a*fter Intervention

Sample	Coliform	E.coli	Feacal Coliform	Staph. Aureus	PCA	Yeast	Mould	Salmonella
Swabs from cows udder and teat EA1	(6.00±1.4) 10^1	0.00	0.00	0.00	(4.70±2.8) 10^3	(4.50±7.1)10^1	0.00	Not Detected
Swabs from production equipment EA2	(5.50±7.1) 10^1	0.00	0.00	0.00	(2.10±2.8) 10^3	0.00	(1.75±3.5) 10^1	Not Detected
Swabs from personal hands EA3	(2.75±3.5) 10^1	0.00	0.00	0.00	(2.25±5.0) 10^3	0.00	0.00	Not Detected
Milk from milking point EA4	0.00	0.00	0.00	0.00	(7.00±1.4) 10^1	0.00	0.00	Not Detected
Received milk EA5	0.00	0.00	0.00	0.00	(3.65±5.0) 10^1	0.00	0.00	Not Detected
Coagulant EA6	(1.00±0.0) 10^1	0.00	0.00	0.00	(7.15±6.4) 10^1	(2.00±0.0) 10^1	(3.50±7.1) 10^1	Not Detected
Mixture of milk and coagulant EA7	(3.50±7.1) 10^1	0.00	0.00	0.00	(8.85±3.4) 10^1	(5.00±1.4) 10^1	(3.35±2.1) 10^1	Not Detected
Heated milk curd EA8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Not Detected
Fresh *wagashi* EA9	0.00	0.00	0.00	0.00	0.00	(1.00±1.4) 10^1	0.00	Not Detected
Fried *wagashi* EA10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Not Detected

Unpublished Laboratory Results from this study.

Table 12. Mean Microbial Counts (cfu/ml or cfu/g) for Processor 'B' during the Processing of *Wagashi* after Intervention

Sample	Coliform	E.coli	Feacal Coliform	Staph. Aureus	PCA	Yeast	Mould	Salmonella
Swabs from cows udder and teat EB1	(5.00±1.4) 10^1	0.00	0.00	0.00	(4.00±2.8) 10^3	(4.25±1.0) 10^1	0.00	Not Detected
Swabs from production equipment EB2	(1.00±0.6) 10^2	0.00	0.00	0.00	(1.95±2.1) 10^3	(4.00±5.6) 10^1	(1.50±7.1) 10^1	Not Detected
Swabs from personal hands EB3	(2.75±3.5) 10^1	0.00	0.00	0.00	(1.10±2.8) 10^3	0.00	0.00	Not Detected
Milk from milking point EB4	0.00	0.00	0.00	0.00	(6.00±1.4) 10^1	0.00	0.00	Not Detected
Received milk EB5	0.00	0.00	0.00	0.00	(9.00±2.8) 10^1	0.00	0.00	Not Detected
Coagulant EB6	(6.50±7.1) 10^1	0.00	0.00	0.00	(2.30±1.5) 10^3	(5.00±1.4) 10^1	(2.00±7.1) 10^1	Not Detected
Mixture of milk and coagulant EB7	(1.59±2.1) 10^1	0.00	0.00	0.00	(5.35±9.2) 10^3	(6.00±0.0) 10^1	(2.25±3.5) 10^1	Not Detected
Heated milk curd EB8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Not Detected
Fresh *wagashi* EB9	0.00	0.00	0.00	0.00	(5.90±9.0) 10^2	0.00	0.00	Not Detected
Fried *wagashi* EB10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Not Detected

Unpublished Laboratory Results from this study.

Table 13. Mean microbial counts (cfu/ml or cfu/g) for Processor 'C' during the processing of w*agashi* after intervention

Sample	Coliform	*Escherichia coli*	Feacal Coliform	*Staphylococcus. aureus*	PCA	Yeast	Mould	*Salmonella*
Swabs from cows udder and teat CC1	(6.00±1.4) 10^1	0.00	0.00	0.00	(4.70±2.8) 10^3	(4.50±7.1) 10^1	0.00	Not Detected
Swabs from production equipment CC2	(5.50±7.1) 10^1	0.00	0.00	0.00	(2.10±2.8) 10^3	0.00	0.00	Not Detected
Swabs from personal hands CC3	(2.75±3.5) 10^1	0.00	0.00	0.00	(2.25±5.0) 10^3	0.00	0.00	Not Detected
Milk from milking point CC4	0.00	0.00	0.00	0.00	(3.00±1.4) 10^1	0.00	0.00	Not Detected
Received milk CC5	0.00	0.00	0.00	0.00	(3.65±2.0) 10^1	0.00	0.00	Not Detected
Coagulant CC6	(1.00±0.0) 10^1	0.00	0.00	0.00	(7.15±6.4) 10^1	(2.00±0.0) 10^1	0.00	Not Detected
Mixture of milk and coagulant CC7	(3.50±7.1) 10^1	0.00	0.00	0.00	(8.85±3.4) 10^1	(5.00±1.0) 10^1	0.00	Not Detected
Heated milk curd CC8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Not Detected
Fresh *wagashi* CC9	0.00	0.00	0.00	0.00	(7.00±4.2) 10^3	(1.00±1.4) 10^1	0.00	Not Detected
Fried *wagashi* CC10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	Not Detected

Unpublished Laboratory Results from this study.

4. Discussion

Findings on the food hygiene practices in this study Table 2 were consistent with that of Nammiaga (as cited in Mirkena, 2010) who reported earlier that microorganisms found in cows' hair, udder, and teats caused inflammation known as mastitis. Further, organisms may enter milk during milking if equipment used is not properly cleaned and sanitized. Although 89.7% of the producers engaged in routine vaccination, 85.5% in regular checks and 97.5% used antibiotics, 45% of the cows were reported to have had mastitis in the last 6 months of the study Table 2. Keskin and Gulsunoghu (2012) also reported that pathogenic microorganisms may enter milk directly via the udder of a diseased or infected animal or indirectly during the milking process due to contamination from the udder and teat, environment, and from contaminated equipment or workers. As presented in Table 2 only about one eighth of the producers washed the udder of cows both before and after milking increasing the risk of microbes infecting both the udders of the cows and the milk obtained from these cows. Similarly, Yilma (2010) identified calf suckle and sometimes udder washing as the common hygienic measures most smallholder farmers took during milking.

The use of equipment with smooth contact surfaces, minimal number of joints, dead ends and crevices such as aluminium and stainless steel has been highly recommended in the production and storage of milk and its products (Saran, 1995; Yilma, 2012). However, only 32.5% of the producers in this study reported using stainless steel equipment during production Table 3. Kurwijila (2006) reported that utensils used in receiving milk contain many crevices, cracks and corners that cannot be easily cleaned hence serve as a conducive environment for harboring spoilage microorganisms. Only about 12.5% of the producers were observed wearing protective clothing Table 4 & 5. A similar observation was made and reported by Kok and Balkaran (2014) who studied a group of food handlers in South Africa. He observed that majority of the food handlers did not wear gloves, hair nets or aprons. Yilma (2012) as a result of similar findings highlighted the need for milk producers to practice a high sense of personal hygiene and maintain good health during production. Using clean utensils during production has been earlier recommended by Kok and Balkaran, (2014)who found that street food vendors who washed utensils in bowls or pots which were also used for cooking and used water that was not changed stood greater risk of contaminating the utensils rather than making them clean. The Australian food standards (2009) postulates that poor milking practices, including dirty chapped or cracked teat, inadequate cleaning and maintenance of milking equipment and poor personal hygiene can lead to contamination of raw milk. Abdulla, et al (2009) reported that equipment and utensils which are not hygienically maintained may cause food poisoning. Lack of refrigeration and storing of both raw and finished products identified in this study Table 6 has been earlier reported by Tessema and Markos (2009) who found that lack of refrigeration facilities at the farm and household levels coupled with high ambient temperature could spoil raw cow milk and its products easily

especially during storage and transportation. From these studies one can say that the 70% of wagashi producers in this study who reported not storing left over cheese in refrigerators in Table 3 do increase the risk of contamination in these products and subsequently food safety risk to consumers.

The average Total Viable Count (TVC) obtained from swabs ranged from 10^7- 10^8 cfu/ml, coliform, feacal coliforms and *Escherichia coli* were in the range of 10^3 -10^5 cfu/ml, 10^3 -10^6 cfu/ml, and 10^3 -10^4 cfu/ml respectively. These high counts from swabs taken from the hands of personnel, milking utensils and cow's udder in this study could be attributed to the fact that milk and *wagashi* producers involved in the milking activities wore no protective coats or clothing, did not wash their hands at all or used dirty water to wash their hands prior to production. According to Yilma (2012), lack of washing and poor sanitization of the udder before milking can impart possible contaminants in milk which could affect the product quality. The high microbial counts obtained when swabs of wagashi processors hands were taken is evident that cleanliness was not up to standards and thus the risk of contamination in the products.

The average *Staphylococcus aureus* counts from the swabs ranged from 10^2 -10^4 cfu/ml. Toxigenic strains of *Staphylococcus aureus* have been implicated in food borne illness and are known to proliferate in conditions of temperature abuse. Ogbolu (2014) also highlighted the global recognition of Staphylococcus aureus as the most important disease causing microorganism that causes intra-mammary infections in dairy cows. He further added that Staphylococcus aureus was found to be high in white cheese around the world.

The total viable counts for milk at milking points (from udder), received milk (in milking utensil) and mixture of milk and coagulant varied from 10^3 - 10^5 cfu/ml. Similar findings were reported by Godefay and Molla (2000) in Ethiopia while studying the bacteriological quality of raw cow's milk taken at different sampling points from four dairy farms and a milk collection centre. Milk from udder and received milk for the production of *wagashi* recorded significant counts for, coliform, faecal coliform and *Escherichia coli* in the range of 10^3 to 10^5 cfu/ml. The isolation and detection of coliform bacteria, *Escherichia coli* and pathogens in milk is an indication of possible contamination of bacteria either from the udder, milk utensils or source of water used (Bonfoh *et al.,* 2003). Yilma, (2012), reported that microorganism that commonly colonized the external surface of the udder and teats include faecal, soil and water coliforms such as *Escherichia coli*, *Enterobacter aerogenes*, *Klebsiella species Streptococci, Staphylococci, Corynefarm* organisms, *Bacilli*, yeast and fungi. The mean total value of *Staphylococci aureus* detected during the study varied from $<10^1$ to 10^5 cfu/ml). Studies have suggested that the presence of *Staphylococcus aureus* on ready-to-eat food may be as a result of improper handling, cross contamination and poor temperature control (Synder, 2009; Christison *et al.*, 2008). Others have reported that *Staphylococcus aureus* is seen globally as the most important pathogen that causes infections in the mammary glands of dairy cows leading to morbidity and mortality in humans when dairy products from such cows are consumed (Ogbolu et al. 2014). Contamination though necessary is not alone sufficient for an outbreak to occur (Adegoke, 2010). Some strains of *Staphylococcus aureus* are known enterotoxin producers (Bryant, 2007), thus having them in any of the samples taken in this study could be a threat to food safety. *Salmonella* has been implicated as one of the leading causes of food borne diseases in the United States of America. Rahman, *et al* (2012) recommended that food safety training is essential for street food vendors to enhance their hygiene practices. This report strengthens the need for educational training for these groups of producers to help them improve their hygiene practices and produce safe milk and wagashi for consumers.

HACCP did help to improve the safety of the products after the intervention. From Table 8 prior to introducing HACCP, *Escherichia coli* and *Staphylococcus aureus* were found in swabs taken from the udder of the cows, equipment and personnel hands but not in the final products like the fresh and fried wagashi and heated milk for processor A . Similar results were obtained for Processor B Table 9 and Processor C Table 10. However, for processor C, molds were found in fried wagashi. After the intervention, *Escherichia coli* and *Staphylococcus aureus* were not found in any o the swabs taken from the udder of cows, hands of personnel, equipment and the finished products as were initially found prior to introducing the HACCP intervention. Yeast were found in samples of fresh wagashi from Processor A after the intervention. For swabs taken from Processor B after the intervention, there were no yeasts or molds in either fresh or fried wagashi in addition to swabs taken from the udders of cows, equipment and hands of producers which had no Escherichia *coli* and *Staphylococcus aureus* present. For Processor C, results were similar to both Processor A and B but with yeast found in fresh wagashi. With drastic reduction in the microbial load found in products from Processor A, B and C, one can deduce that the HACCP intervention did help reduce the microbial contamination in the process and thus improved the safety of products. There was a significant difference ($P \geq 0.05$) in the microbial load of wagashi from the selected producers with Producer B having the least microbial contamination both prior and post intervention and thus had the safest products. There was a significant difference in the microbial loads of wagashi from the different

producers. Certain food and personal hygiene practices like hand washing, wearing clean or protective clothes during production, cleaning and sanitizing equipment among others were identified as main sources of microbial contamination in milk and wagashi production. The HACCP intervention did greatly help to reduce microbial contamination in the products making them safer. It is thus concluded that engaging in hygienic practices can help improve the safety of milk and wagashi.

5. Conclusions

In conclusion, locally manufactured milk and wagashi produced in the Sissala district of the Upper West region of Ghana has been identified as a high risk food due to the high rate of contamination. There is therefore the need to adopt hygienic practices and prevention measures like the application of HACCP to the production of milk and wagashi to improve its safety for consumers. Probably, standardizing the production methods will help set a benchmark for minimum standard of milk and wagashi quality.

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