AN ASSESSMENT OF THE PRODUCTION PRACTICES AND QUALITY OF MILK USED BY LOCAL DAIRY PROCESSORS IN THE KUMASI METROPOLIS AND ASOKORE MAMPONG MUNICIPALITY OF THE ASHANTI REGION OF GHANA

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ABSTRACT
A study was carried out to investigate the production practices, hygienic standards and microbial load in raw milk used in the production of three local dairy products ('Wagashi', 'Fura da nono' and 'Burkina') from five urban markets in Kumasi, Ghana. Data were collected with content-validated and structured questionnaires, designed to seek information on the demographics of respondents, source and type of milk used, scale of operation/production, hygienic practices and standards employed and packaging methods for small-scale dairy processors. Milk samples from processors were obtained for microbiological analysis. The analysed results revealed that local dairy processing is dominated by small-scale middle aged women without any formal training in milk processing. Production was mainly done outdoors and hygienic standards employed were not optimum. Bacteria count from milk samples taken from all the five markets exceeded the standard (1×10^4 Cfu/ml) for bacteria testing which rendered the milk unwholesome. Results of biochemical test confirmed the presence of E. coli in the milk samples of all but one market in the study area. The study concluded that bacteria count from the milk samples exceeded the standards for bacteria testing which made them unwholesome for human consumption. Contamination from the kraal and poor hygiene after pasteurization and during processing were identified as possible causes for the high bacterial loads in the milk samples.

Keywords: *'Wagashi', 'Fura da nono', 'Burkina', local dairy product, bacteria, raw milk*

INTRODUCTION
The production of local dairy products as a business venture has gained popularity among local small-scale dairy producers in Ghana. Many of these small-scale producers are women who handle less than 15 litres of milk per day (Omore *et al.,* 2009). According to the authors however, business oriented small-scale dairying has higher returns than many traditional agricultural activities which provide income for producer households. Dairy consumption in Ghana may be linked to factors such as income level of household head, level of urbanization of consumer location and distance from home to dairy purchase point (Aidoo *et al.,* 2019).

Local dairy products like 'Wagashi' (local soft cheese), 'Burkina' ('Dege') and 'Fura da nono' are usually operated on a small-scale platform in Ghana. 'Burkina', a fermented milk and millet smoothie, is a popular indigenous beverage in Ghana with its production being dominated by the Northern regions (Baidoo and Kunadu, 2018). Wagashi (local soft cheese) is associated with the nomadic Fulani as it is their way of preserving excess milk for future consumption or sale. According to Elkhider *et al.* (2011), 'Wagashi' can contribute to solving problems related to protein deficiency in Africa. "Fura' is a cereal ball prepared mostly with mashed millet and blended with raw milk ('Nono'). Jideani and Wedricha (1994) described 'Fura' as a semi-solid dumpling millet-based meal that is consumed in Ghana and the Northern parts of Nigeria. Patronage of 'Wagashi',' Burkina' and 'Fura da nono' and other local dairy products have been low due to quality and safety gaps associated with the traditional production according to Baidoo and Kunadu (2018). Other factors that contribute to the low patronage include: unsanitary production environment, contaminated water used in cleaning food contact surfaces, improper hygienic practices of producers and use of inadequately washed utensils (Baidoo and Kunadu, 2018). The afore-mentioned reasons are legitimate in that milk serves as an excellent growth medium for microorganisms (Soomro *et al.,* 2000). Raw milk is also a channel for the transmission of zoonotic and other pathogens to humans through contamination from cow dung (Mac Donald *et al.,* 1988). Because there has been an increase in consumers' desire for healthy and safe food, wealthier city dwellers demand good quality heat-treated milk products such as fresh cream and ice-cream and are willing to pay premium prices for such products (Osafo *et al.,* 2000).

Packaging, presentation and preservation practices for these local dairy products do not normally conform to acceptable standards even though of late some producers of "Burkina" in particular have made attempts to put labels on their packaging. 'Burkina' is mostly sold in plastic bottles and most of the time exposed to the sun during hawking while 'Wagashi' is sold in fresh or fried forms on trays without packaging. 'Fura da nono' is kept and sold in transparent glass-wooden boxes. These practices can reduce the shelf-life of the products due to possible contamination thereby drastically reducing the profit margin of producers. This study sought to investigate the practices and processes involved in producing 'Wagashi', 'Burkina' and 'Fura da nono' at some urban markets in order to optimize their standards for longer shelf-life and more patronage. Specifically, the study sought to:

i) investigate the processes involved in the local production of 'Wagashi', 'Burkina' and 'Fura da nono' and the hygienic standards employed in production and packaging.
ii) determine the microbial load of cow milk used by local small-scale producers of 'Wagashi', 'Burkina' and 'Fura da nono'.

MATERIALS AND METHODS

Study Area

The study was conducted in five selected urban market communities in the Kumasi Metropolis and Asokore Mampong Municipality namely: Aboabo, Sawaba, Asawase, Alabar and Akorem. These markets were selected because they are focal centres in Kumasi where traditional dairy foods are mostly produced and sold. The microbiological analysis was carried out at the Microbiology Laboratory of the Department of Animal Science, Kwame Nkrumah University of Science and Technology.

Sampling technique

The random sampling technique was employed at the various markets within the communities. This technique was not biased on each member of the study as it gave each member of the population of traditional dairy food producers an equal and independent chance of being included in the sample. Out of a population of 100 traditional dairy food producers in the five selected communities, a sample size of 50 was chosen which represented 50% of the population. 50 questionnaires therefore were administered to the selected sample size with varying number of respondents from each community.

Data collection

Data were collected with content-validated and structured questionnaires for the small-scale dairy processors/sellers. The structured questionnaire which was the main instrument for the data collection consisted of both open ended and close ended questions. The questionnaire was designed to seek information on the demographic data of respondents, source and type of milk used, scale of operation, training needs of respondents, hygienic practices during processing/ preparation of product, storage and shelf-life of product and packaging of products. Observations about the sanitary conditions surrounding the processing units and selling points were made.

The markets were conveniently designated A, B, C, D and E for Alabar, Asawase, Akorem, Aboabo and Sawaba, respectively. Three milk samples each were purchased from each of the five markets within the communities under study. A total of fifteen pasteurized milk samples were thus collected aseptically into sterilized containers and conveyed to the laboratory on ice for further analysis. The samples purchased were pasteurized raw milk from the producers of 'Wagashi', 'Fura da nono' and 'Burkina'. The milk products were labeled according to the market to aid in determining the microbial load in the milk from the respective markets.

Laboratory analysis

Chemical reagents

The chemical reagents used were products of Oxoid Laboratories, Basingstoke, Hampshire, England and Biomark laboratories, India. These chemical reagent included MacConkey agar for the isolation of gram-negative organisms. Plate count agar used for the isolation of total viable count and Peptone, citrate and indole for biochemical tests .

Preparation of nutrient agar

Twenty-eight grams of nutrient agar powder was suspended in 1litre of distilled water. It was heated and stirred to form a uniform mixture. The dissolved mixture was autoclaved at 121ºC for 15 minutes. The mixture was then cooled and poured into sterilized petri dishes. Nutrient Agar is a general-purpose nutrient medium frequently used for the growth of a variety of bacteria and fungi.

Preparation of MacConkey agar

Fifty-two grams of MacConkey agar powder was suspended in 1 litre of distilled water. It was stirred to form a uniform mixture. The mixture was autoclaved at 121ºC for 15 minutes. The mixture was cooled and poured into sterilized petri dishes. MacConkey agar is used for the isolation of gram-negative enteric bacteria such as *Escherichia, Salmonella, Klebsiella* and others.

Preparation of Peptone water

Peptone water medium was prepared by dissolving 15g of the peptone powder into 1litre of distilled water. The mixture was stirred and distributed into test tubes which was then autoclaved at 121ºC for 15 minutes.

Total viable count

The total viable counts of the 15 pasteurized milk samples collected were analyzed to estimate the population of microorganisms. The Total Viable Count of bacteria in the pasteurized milk was determined using the spread plate technique on nutrient agar (NA) (Oxoid CM 0003; Oxoid Ltd Basingstoke, Hampshire, England). Serial dilutions of 10^{-1} to 10^{-4} were prepared by placing 1 ml of the milk sample into 9 ml of sterilized distilled water to obtain 10^{-2}. This procedure was repeated for 10^{-3} and 10^{-4} . Then 0.1µl aliquots from each of the dilutions were inoculated into labeled petri dishes containing the solidified nutrient and MacConkey agar and uniformly spread using a spreader. The plates were incubated for 24hrs at 36 °C (±1). After the incubation, colonies between 30 to 300 were counted using a colony counter (Stuart Colony Counter, UK) and the average colonies were calculated from which the total viable count was estimated using the formula;

$$\text{Cfu} = \text{Average colonies x } \frac{\text{Dilution}}{\text{Aliquot plated}} \text{ and expressed as Cfu/ml}$$

Biochemical test to confirm the presence of Escherichia coli

A biochemical test was employed to confirm the presence of *Escherichia coli*. This was because MacConkey agar gave a presumptive identification of the isolated organisms. This was done by the citrate and Indole test.

Citrate Utilization test

Fifty-two grams of the chemical was dissolved in l litre distilled water. The mixture was stirred and sterilized for 15mins at 121ºC. The milk samples were inoculated in the citrate solution and incubated at 36ºC (±1) for any color change. No color change indicated no growth of microbes but a change in color confirmed growth of microbes.

Indole test

Milk samples were inoculated in tryptone solution and incubated at a temperature of 37ºC. Few drops of Kovacs reagent were added. Formation of red ring coloration on the top indicated a positive test for *E. coli.*

Statistical Analysis

Data collected were checked for consistency, coded and entered into the Statistical Package for Social Sciences (SPSS, 2007) version 21. Data were analysed using descriptive statistics and the results presented as frequency and percentage in tables, pie charts and bar charts. Microsoft Excel version 2016 was used to tabulate and summarize findings of the laboratory analysis of milk samples.

RESULTS AND DISCUSSION

Demographic data of respondents

The demographic characteristics of respondents in the survey are presented in Table 1. More than 70% of the respondents were between the ages of 13-35 years with only 12% being above 45 years. This typically shows that majority of respondents were in the active labor force. Thus, given the right training and extension education, their productivity could be high. This information is similar to the data from Ghana Statistical Service (GSS, 2016) labor force survey which stated that majority (90%) of the currently employed population in the informal sector was 15 years and older. From Table 1, majority of the respondents were females (86%) showing that the informal local dairy industry is gender-biased in favor of females.

Table 1 further shows that more than half (56%) of the respondents did not have any formal education. Majority of the number who had had some exposure to formal education were primary

Table 1: Demographic data of respondents

Parameter	Detail	Frequency	Percentage
Age (in year)	13 – 19	10	20
	20 – 35	26	52
	35 – 45	8	16
	>45	6	12
	Total	50	100
Gender	Male	7	14
	Female	43	86
	Total	50	100
Educational level	Primary	8	16
	JHS	7	14
	SHS	5	10
	Tertiary	2	4
	No formal education	28	56
	Total	50	100
Training in milk processing	Yes	8	16
	No	42	84
	Total	50	100
Ethnicity	Gonja	11	22
	Fulani	18	36
	Zabarma	15	30
	Hausa	6	12
	Total	50	100

school graduates. Thus the rate of adoption of new technology among respondents will be low since according to Ani *et al.* (2004), the rate of adoption of new technology among people who have had some formal education is high. Only 16% of respondents had undergone some formal training in milk processing from health institutions and non-governmental organizations by way of workshops. The greater majority (84%) had no formal training in milk processing but relied on local indigenous knowledge to work. Majority of respondents (36%) were Fulani women who process the milk in excess of what their families required into 'Wagashi' mainly and 'Fura da nono' (Figure 1) for supplemental income. The Fulanis are followed closely by the Zabarmas (Table 1), some of whom are foreigners from Niger, who were mainly into Burkina and Wagashi production as shown in Figure 1.

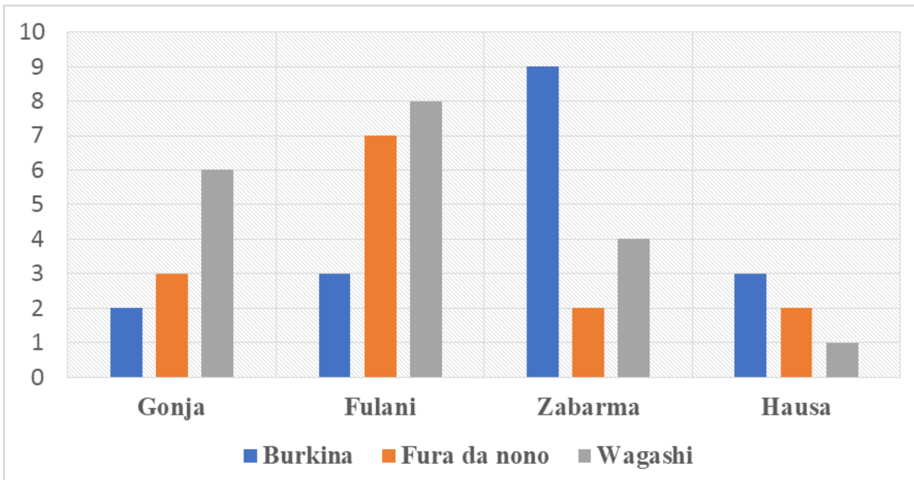

Figure 1: Local dairy products produced by the various ethnic groups in the study area

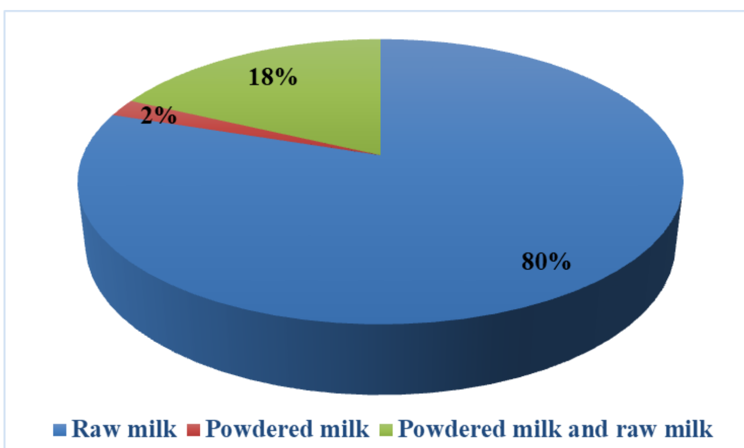

Figure 2: Types of milk used by local dairy processors in the study area

Types and sources of milk used by local dairy processors

Most of the respondents (80%) used solely raw cow milk directly from the farm or kraal (52%) for their products (Figures 2 and 3). Of the 80% that rely solely on raw cow milk, 14% got their supplies from assemblers (who buy the raw milk from several farms and sell to processors) while 12% bought theirs from women who hawked the raw milk. This observation is in line with the report of Omore *et al*. (2009) that marketing agents such as assemblers and hawkers are involved in the supply of milk to processors. Eighteen percent (18%) of respondents used both raw cow milk and powdered milk from the local market and shops due to the seasonal changes and fluctuations in the supply of raw cow milk. Only 2% of the respondents (Figure 2) relied solely on powdered milk from the local markets and shops for their production.

Hygienic practices during production

The scale of operation is determined by the average number of litres of milk used per week by a producer. The bulk of the respondents (88%) operated on a small scale using between 5-10 litres of milk a day while the remaining 12% operated on a medium scale using between 10-15 litres of milk a day as shown in Table 2. Omore *et al.* (2009) reported a similar observation that many small-scale dairy producers handled less than 15 litres day.

Majority of the respondents (86%) did not have dedicated indoor premises for processing their milk as shown in Table 2 and so operated from outside sometimes near gutters which exposed cooking utensils and milk to flies, pathogens and other contaminants. The washing of utensils and containers before, during and after processing was mostly done with water, soap/detergent and sponge (52%). Interestingly, some respondents used only boiled water (2%) and just water and sponge, with no soap/detergent (42%). Water and sponge only are not enough to eliminate contaminants on utensils. Before processing, majority of respondents (62%) filtered their milk with a piece of clean cloth (36%) and a net sieve (26%) to remove any foreign matter. Thirty eight percent (38%) do not filter milk before processing. The respondents mostly used charcoal (58%) and firewood (42%) as their energy source for processing milk. The use of these fuel sources could contaminate during processing.

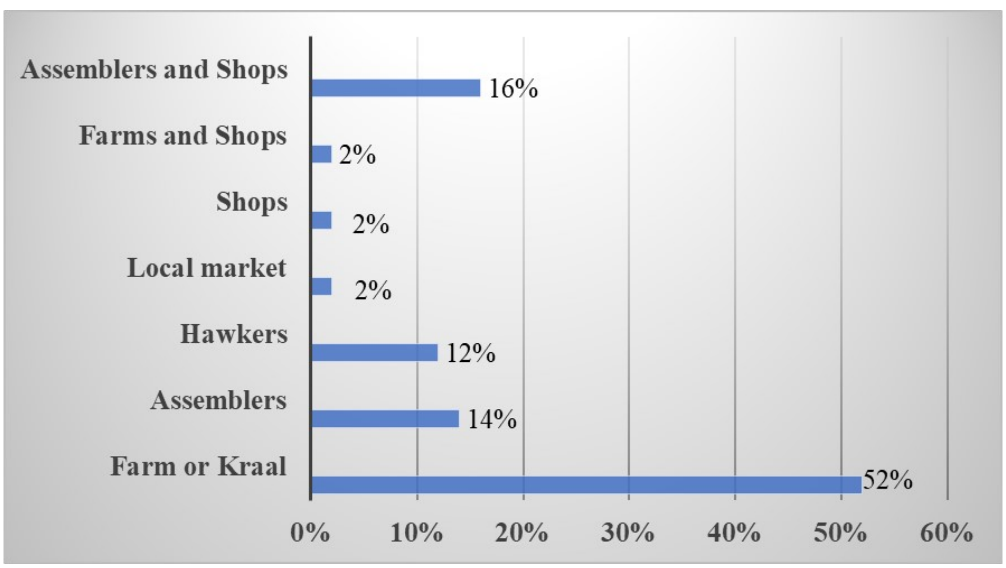

Figure 3: Sources of milk for local dairy processors in the study area

Table 2: Scale of operation and hygienic standards during processing

Parameter	Detail	Frequency	Percentage
Scale of operation	Small scale	44	88
	Medium scale	6	12
	Large scale	0	0
	Total	50	100
Processing location	Indoors	7	14
	Outdoors	43	86
	Total	50	100
Cleaning of utensils	With boiled water	1	2
	With water and sponge	21	42
	With water and detergent	2	4
	With water, soap and sponge	26	52
	Total	50	100
Sieving of milk	With a clean cloth	18	36
	With a net sieve	13	26
	No sieving	19	38
	Total	50	100
Source of fuel	Charcoal	29	58
	Firewood	21	42
	LPG	0	0
	Total	50	100

Packaging and shelf life of locally manufactured dairy products in the study area

All 'Burkina' processors/sellers used transparent plastic bottles for packaging their products (Table 3). 'Wagashi' has varied packaging methods from different combinations of transparent and black polythene bags. Half of the 'Wagashi' processors packaged with both transparent and black polythene bags whereas 28% packaged with only transparent bags. 'Fura da nono' processors used transparent and black polythene bags (47%) and disposable cups (26.5%) for all categories of customers while 4% used plastic bowls for customers who wanted to consume the product at the premises as shown in Table 3.

Table 3 also shows that majority (65%) of 'Burkina' processors reported the shelf life of their products to be 1-3 days while the remaining 35% indicated 4-6 days shelf life after preparation. 'Wagashi' was reported to last for 1-3 days by majority (67%) and 4-6 days by the rest (33%).

Most processors of 'Fura da nono' said the products last for 1-2 days while the rest reported a longer shelf life (Table 3). It was observed that most of the locally produced dairy products had shorter shelf life perhaps due to poor post-pasteurization handling and preservation. According to Cromie (1991) shelf life is influenced by post pasteurized storage conditions, packaging adopted and extent of post pasteurization storage.

Table 3: Packaging and shelf life of local dairy products in the study area

Property	Product	Detail	Frequency	Percentage
Packaging	'Burkina'	Plastic bottles	17	100
		Total	17	100
	'Wagashi'	Transparent and black polythene bags	9	50
		Only transparent polythene bags	5	28
		Only black polythene bags	4	22
		Total	18	100
	'Fura da nono'	Transparent and black polythene bags	7	47
		Disposable cups	4	26.5
		Polythene bags and plastic bowls	4	26.5
		Total	15	
Shelf life	'Burkina'	days	11	65
		4 – 6 days	6	35
		Total	17	100
	'Wagashi'	1- 3 days	12	67
		4 – 6 days	6	33
		Total	18	100
	'Fura da nono'	1 -2 days	9	60
		3 – 5 days	3	20
		6 – 7 days	3	20
		Total	15	100

Total plate count of milk samples

According to the International Bacteria Testing for Raw milk (reference required here), bacteria in pasteurized milk should not exceed 1 x 10^4 Cfu/ml. Bacteria count from the milk samples taken from all the five markets exceeded the standards for bacteria testing (Table 4) which made them unwholesome. Cfu/ml above 1 x 10^4 indicates that hygienic standards are poor. This observation is similar to the report of Soomro *et al*. (2002) who in a similar study observed that the safety of milk used for production of 'Wagashi', 'Burkina' and 'Fura da nono' could not be guaranteed because milk serves as an excellent growth medium for microorganisms.

These high bacteria populations in the milk may have been due to a combination of factors such as poor cleaning of utensils and equipment, poor preservation or refrigeration and generally poor hygienic standards. Psychotropic bacteria counts tend to be higher in milk and are often associated with occasional neglect of proper cleaning and sanitizing procedures (Olson and Mocquat, 1980; Thomas *et al.,* 1966). Some milk residues left on utensils due to improper cleaning may create contact surfaces to support the growth of a variety of micro-organisms. Also under poor conditions of refrigeration, bacteria other than psychotrophs are able to grow rapidly and could become predominant in milk.

The pH of the milk samples is also presented on Table 4. The normal pH of pasteurized raw cow milk per industry standard is 6.5-6.75 (Marouf and Elmhal, 2017). The pH of 'Wagashi' and 'Fura da nono' from all the five markets was within the normal range aforementioned. Milk samples from Asawaase and Sawaba for 'Burkina' were outside the normal pH range of 6.6-4.5.

Milk from Alabar, Akorem and Aboabo recorded relatively lower pH and had a thick curdled appearance, similar to the finding of Anderson *et al.* (2011) where a milk sample with a pH of 4.0 had a rancid odour and curdled appearance.

Table 4: Total viable count and pH of the milk samples from the study areas

Market	Cfu/ml (colony forming unit per ml)			pH		
	'Wagashi'	'Fura da nono'	'Burkina'	'Wagashi'	'Fura da nono'	'Burkina'
A	$3.4x10^4$	$6.9x10^6$	$1.3x10^5$	3.78	4.59	4.02
B	$1.5x10^5$	$1.9x10^5$	$2.2x10^6$	3.98	4.77	7.09
C	$2.6x10^4$	$2.0x10^7$	$1.2x10^7$	3.93	4.55	4.04
D	$1.6x10^5$	$1.9x10^5$	$1.1x10^5$	4.14	4.17	4.03
E	$2.9x10^5$	$2.2x10^5$	$2.2x10^6$	3.83	4.17	7.08
Mean	$1.3x10^5$	$1.4x 10^7$	$3.3x10^6$			

A=Alabar, B= Asawaase C= Akorem D=Aboabo E= Sawaba

Milk samples from Asawaase and Sawaba had a homogenous appearance with relatively higher pH than 6.6. Anderson *et al.* (2011) have also reported similar higher pH of 7.0 and concluded that spoilage was evidenced by curdling and rancid odour. Again, when milk reaches pH levels below 4.5, the acidic conditions can cause precipitation of casein micelles and lead to curdling (O'Connor, 1995). The high total plate counts (Table 4) of the milk samples may have reduced the freshness of the milk products.

Biochemical test on milk samples

Results of biochemical tests carried out on the milk samples for the presence or otherwise of *E. coli* are presented in Table 5. With the exception of Alabar market, milk samples from all other markets in the study area had *E. coli* isolated from them in one or more of the milk samples (Table 5). Out of the samples taken from Akorem for the three products, *E. coli* were isolated from samples from two products which was a pointer to the fact that milk quality and handling in that market was unsatisfactory. Even though the milk had been pasteurized, there were still isolations of *E. coli* in some samples which is comparable with the findings of Anderson *et al.* (2011). According to Singleton (1999), *E. coli* are bacteria found in the lower intestine of warm - blooded animals, thus the presence of these organisms in milk were indicative of fecal contamination possibly during milk extraction.

The milk could have also been contaminated by unsanitary handling after the completion of the pasteurization process. It is also worth noting that milk samples for 'Fura da nono' from all five markets were free from *E. coli* (Table 5).

Table 5: *E.coli* test results of milk from the five markets

Market	Presence *of E. coli*		
	' Wagashi'	'Fura da nono'	'Burkina'
A	*E. coli*	No *E. coli*	No *E.coli*
B	No *E. coli*	No *E.coli*	No *E.coli*
C	*E. coli*	No *E. coli*	*E. coli*
D	*E. coli*	No *E .coli*	*E.coli*
E	No *E. coli*	No *E. coli*	No *E. coli*

A=Alabar, B= Asawaase C= Akorem D=Aboabo E= Sawaba

CONCLUSIONS

Local dairy processing in the study area was dominated by small-scale middle aged women without any formal training in milk processing. Manufacturing places and processes were rudimentary, and possibly the sources of microbes into milk; an observation that has been a source of worry for many consumers. Contamination likely occurred along the chain of production, from the kraal, during processing and during packaging.

Bacteria count from milk samples taken from all the five markets in the study area exceeded the standards for bacteria testing which made them unwholesome for human consumption.

In particular, the presence of *E. coli* in milk samples from all but one market in the study area testified that hygienic practices and standards were not the best. Finally, most of the locally produced dairy products had shorter shelf life perhaps due to the poor post-pasteurization handling and preservation.

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