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"Hygiene does not affect our cheese quality": A qualitative assessment of traditional cheese processors in Ghana

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ABSTRACT

Consumer preference surveys in many developing regions have revealed low confidence for traditional dairy products because of perceived poor safety and unhygienic practices of the processors, especially those who are low literate. Many of these products are therefore restricted to informal settings, and traditional product certification is rare. The current research has a social orientation and examines the current state of knowledge, attitudes, and practices among female cheese processors in cattle rearing villages in Southern Ghana. Semi-structured, one-on-one interviews combined with on-site observations were conducted during a mini survey. The results showed that traditional cheese processors were conversant with process controls, non-processing and processing factors that could influence the quality of their products but did not consider safety and hygiene as a critical factor. Many of the processors had poor knowledge, incorrect attitudes, and were engaged in suboptimal practices that were likely to result in poor product safety and quality.

1. Introduction

Traditional dairy processing in many developing countries is underdeveloped but contributes significantly to the diet and livelihoods of consumers and processors, respectively. The continued growth and presence of modern dairy processing firms led to consumer preference surveys for local modern and traditional dairy products. In many developing countries, the findings showed that consumers resorted to modern products for the same dairy product category because of their perceived safety, but valued traditional products for their taste, lower price, and perceived superior nutrition. For example, consumer surveys by Staal, Pratt, and Jabbar (2008) in Kenya and Ethiopia showed that traditional products had poorer microbial quality but were preferred over modern products because both high-income and resource-poor consumers preferred the tastes and affordability, respectively. Another study in Ghana's capital by Kunadu et al. (2019) revealed that consumer confidence was often higher for multinational dairy brands due to perceptions of poor processing practices and poor safety among traditional dairy processors and these perceptions may influence purchasing and consumption patterns and potentially influence intervention efforts to boost the traditional dairy industry.

Indeed, several microbial studies have found that the level of pathogens in dairy products depends on whether processors control hazards (before, during, or after processing) or are a well-known consumer brand or not. For example, an evaluation of the microbial quality of fifty-five (55) raw milk cheese samples produced by small farms with no safety protocols and commercial deli markets with safety protocols in parts of Brazil by Moraes, Viçosa, Yamazi, Ortolani, and Nero (2009) showed higher levels of pathogenic microbes than the legally allowable limits in all samples at the point of retail. In Jordan, a similar study by Gharaibeh (2017) of eight (8) branded and unbranded *Labneh* cheese samples collected from local markets showed significant differences in the levels of pathogens. Unbranded *Labneh* had higher than the legal limits for coliforms, yeast, and mold, while branded ones were microbiologically acceptable. In summary, although the microbial content of both modern and traditional products may be controlled during processing, less standardization of procedures for traditional dairy products may make them unsafe.

Implementing food safety practices among traditional dairy processors often needs education and training on food safety principles. However, different sized firms often have different compliance expectations, depending on the type of food safety

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program. For example, in the United States of America, several authorities [such as the Food and Drugs Authority (FDA), Center for Disease Control (CDC), United States Department of Agriculture (USDA), Department of Health Services (DHS), and Environmental Protection Agency (EPA)] handle different sections of the food supply chain to control contamination, but often require training to be conducted and evaluated by trained and certified individuals. Local food authorities also conduct food safety training for different sized firms in many developing countries. However, such modes of education or training can be ineffective for traditional processors who are non- or low literate, depending on the mode of delivery. Omore et al. (2009), upon a thorough analysis of dairy products processing in Ghana and Tanzania, concluded that several opportunities existed for intervention, particularly with marketing, public health issues, and indigenous processing.

In legally regulated cheese processing industries, several process controls are often implemented to guarantee the safety and consistent quality of the products. These include monitoring the nutritional composition of milk depending on the cheese type, monitoring acidity, salt content, cooking time and temperature, and regulating conditions under which curds are treated to maintain standards of identity. However, traditional cheese processing, especially in low-income countries, may be done under low regulations, the absence of standards and documentation, and relying on generational knowledge (Omore et al., 2009; Owusu-Kwarteng, Akabanda, Agyei, & Jespersen, 2020; Paxson, 2013). There are very few studies evaluating the food safety behavior of traditional processors considering the dendritic nature of the dairy supply chain and individual factors (process controls or otherwise) that may affect their processing outcome. Traditional dairy products are also thought to be made by processors with little or no Food Science knowledge and have different target markets and access. However, the broader consumer consensus is that traditional products are unsanitary.

This study's overarching goal was to assess the adoption of food safety and hygiene practices by interacting with traditional cheese processors in cattle rearing villages in Southern Ghana and use the information to build a food safety training program that may improve their processing scale and conditions. More specifically, the study sought to determine if there is an inter-processor difference or not in process controls that are implemented, how they are implemented at such operational levels are and whether these opinions affect the quality of traditional cheese products marketed in Ghana. It is hypothesized that traditional dairy processors are not conducting their activities in line with well-established local and international processing standards that have been proven critical for product safety.

2. Methods

A mini survey was conducted using a rapid appraisal method to carry out a formative evaluation of the current state of the processors' knowledge, attitudes, and practices. Semi-structured, one-on-one interviews combined with on-site observations were conducted for twenty-six (26) cheese processors who were selected using non-probability sampling. Processors were selected from cattle rearing villages in Southern Ghana (Table 1), where considerable cheese processing activity occurs. Due to surges of covid-19 in Ghana and the restriction of movement in parts of the country during the study, efforts were made to choose a representative sample in any given location as shown in Table 1. In addition, non-participating producers in the locations visited had similar assets and processing protocols, received milk from the same kraals and retailed to similar markets. The specific cheese type is locally known as Wagashi.

The main objective was to capture the respondents' knowledge on food safety and hygiene practices during traditional cheese processing, their attitudes towards incorporating such behavior in their operations, and their practices during regular operations from raw material through retail. The hypothesis was that all traditional cheese processors have poor food safety and hygiene knowledge, attitudes, and practices. The interviews were also meant to help identify challenges faced by processors, assess the influence of supply chain factors, if any, and establish reference values for an educational intervention. Interviewees were given a brief background on the subject, and consent was sought prior to interviewing and observing their processing activities. The semi-structured questionnaire was developed using the Code of Hygiene practice for milk and milk products (FAO, 2009) and reference material from the Ghana Code of Hygienic Practices and the SSAFE Global Dairy Farming Food Safety Training framework. The interview covered demographics, a description of the processing environment, process controls, and the processors' opinions on processing, hygiene, and food safety. To be included in the study, cheese processors who consented to the study were required to meet the following criteria: be uncertified by the Ghana Food and Drugs Authority; live and conduct processing activities in the study area; have no accredited or formal food hygiene training and operate on a micro to small scale according to definitions by the Ghana Statistical Service.

2.1. Scoring

Using a scoring system, answers for knowledge were scored one point for correct answers and zero for wrong answers or if respondents answered no/do not know. Attitudes were ranked based on three score levels; agree (two points), neutral (one point) or disagree (zero points). Practices were self-reported answers to open-ended questions and compared to observations. The answers given were coded based on whether they were a best practice (two points), good/acceptable practice (one point) or a poor practice (zero points). The coded practices were further ranked based on the rate at which they were practiced spanning from always (two points), sometimes (one point), to never (zero points). Multiplication of the codes with the ranks gave a final score that was recorded as the respondent's practice score for a question (example: if a respondent's particular practice was best (two points) and they always (two points) carried this out, then their score for that

Table 1
Study locations in Ghana.

Processor locations	Description	District	Administrative region	Number of processors counted	Percentage included in study
Aveyime-Battor	Rural	North Tongu	Volta	15	73
Akuse	Rural	Lower Manya Krobo	Eastern	7	70
Agomeda	Rural	Dangbe West	Eastern	3	100
Dodowa	Peri-urban	Shai Osudoku	Greater Accra	2	100
Sasaabi	Peri-urban	Shai Osudoku	Greater Accra	1	100
Tulaku	Low-income urban	Kpong Katamanso	Greater Accra	2	100

practice would be four (4). The total practice score was then calculated for each participant. The higher the scores, the better the respondents' knowledge, attitudes, and practices were assumed to be towards food safety and hygiene. Using Bloom's cut-off points, if the total percentage of correct knowledge answers or the percentage of desired or positive attitudes, or the percentage of optimal practices was less than 60%, the respondent was at considerable risk for food safety issues. They were considered a medium risk for scores between 60% and 79%. For scores above 80%, they were considered a minimal risk (Table 2).

Table 2
Score classifications.

Total knowledge score	Total attitude score	Total practice score	Score (%)	Level
11–13	16–20	16+	80–100	Good
8–10	12–15	12–15	60–79	Average
<8	<12	<12	<60	Poor

2.2. Statistical analysis

Descriptive statistics (mean, median, range, frequencies, and percentages) analyzed quantitative and categorical variables. Open-ended answers were analyzed in MS–Excel by creating sub-categories and calculating frequencies for repeating themes. Cross tabulations, the Fisher Exact test (for nominal data) and Mann–Whitney U test (for ordinal data and nominal data comparisons) were conducted using SPSS version 25 to test associations between demographic variables, processor characteristics and the association among knowledge, attitudes, and practices.

3. Results

3.1. Processor characteristics

Tables 3 and 4 show demographic information and other processor characteristics. Twenty-six (26) female processors were interviewed. The majority (50%) of the respondents were less than 31 years old. The majority were multilingual, with Fula as their primary language but could also fluently speak and understand other Ghanaian languages, specifically Hausa, Dangbe, Ewe, Twi, Ga, and English. Most participants lived and operated in areas classified as rural, and the majority (90%) had not received any formal education.

Although the study was targeted at cheese (Wagashi) processors, a minority of the respondents also engaged part -time in other agricultural activities like vegetable farming and cattle rearing and food service activities. All respondents reported not seeking any formal training for cheese making; most of their skills came from adult family members who were or had been cheese processors. While most processors owned their operations, their primary role in the supply chain was to distribute wholesale quantities of fresh cheese to retailers and other foodservice actors in informal markets for further processing into other forms (smoked/fried Wagashi). Very few processors doubled as wholesale distributors and retailers, but the products were sold fresh in such cases.

Many cheese processors did not have a government-approved health certificate often mandated for food handlers. The few who did had acquired them for other foodservice activities and not cheese processing. Many of the processors also had full access to working smartphones and electricity.

Table 3
Demographic characteristics of cheese processors (n = 26).

Demographic variable	Status	(%)
Age distribution	18–30 y	50.00
	31–50 y	30.77
	51+ y	19.23
Language	Multilingual	
	Fula (primary)	76.92
	Other (primary)	15.38
	Unilingual	7.69
Location	Rural	65.38
	Peri-urban	11.50
	Urban (low income)	26.92
Education	None	90.00
	Primary School	19.20
	Secondary School	11.54

3.2. Description of the processing environment

The cheese type processed, locally known as Wagashi, can be described as a soft, fresh unripened cheese made from whole milk. Cheese (Wagashi) was often processed in an enclosed and poorly ventilated area. A simple structure usually made from wood, thatched roofs, and sandy floors was often designated solely for cheese processing. Most processing areas had no windows. Firewood, the primary fuel source, was stored inside the processing area in many instances. Most processing areas were in close vicinity to cattle kraal. Some processing areas were shared with farm animals. In these cases, some sort of barrier was mounted to prevent animals from freely walking into the processing space while it was in operation. Aluminum pots were the main utensil for preparing the cheese. *Calotropis procera*, the plant from which the coagulant was extracted, was sourced locally from the neighborhood. The coagulant was extracted by pounding in wooden mortars with a wooden pestle. The straining and molding of the cheese (Wagashi) curds was done with wooden baskets. In very few instances, plastic molds were used. The process flow is described in Fig. 1.

All the processors used salt and *Calotropis procera* stem (coagulant source) as the only other ingredients apart from whole raw milk for making Wagashi. They all knew the purpose of *Calotropis procera*, but many could not explain the function of the salt. *Calotropis procera* plants were uprooted from the immediate vicinity to isolate the coagulant of interest. The leaves were removed, and the stem was cut up into pieces. Depending on the quantity of milk, an appropriate amount of cut stem was pounded using a wooden mortar and pestle. The average quantity observed was to use 0.5 m of stem for about twenty-five liters of fresh milk. The pounded mash was mixed with about a cup or two of water and, in rare instances, milk. The resulting solution was strained directly into a large cooking pot containing cheese milk during the cheese making process. All measurements were done according to each processor's knowledge. Measurements conducted on-site revealed that the average pH of the milk was 6.7 before the addition of the coagulant and 6.3 after curd formation began. The average temperature at which curd formation began was 75 °C. After the curds were formed, they were drained and flipped a couple of times to attain the final form. After this step, no further treatment was given, and the curds were distributed. Some distribution practices included leaving the curd in whey until they reached the next point in the supply chain or keeping them in cool water to prevent them from sticking to each other. Only one (1) processor mentioned sun-drying the curds to reduce the moisture content, but this was not directly observed.

3.3. Knowledge

Three broad indicators were used to assess participants' knowledge. These were hazards and process controls, sanitation,

Table 4
Processor characteristics (n = 26).

Characteristic	Status	Percentage
Occupation	Cheese only	61.54
	Cheese & other agricultural activity	11.54
	Cheese & other food service activity	23.08
Training type	Informal via predecessor	100
Operation type	Self-owned	92.30
	Apprentice	7.69
Retail mode	Informal market & wholesale distributor	76.92
	Informal market & wholesale distributor & other	23.07
Health certificate	Yes	11.53
	No	88.47
Smartphone	Yes	53.84
	No	46.16
Electricity	Yes	69.23
	No	30.77

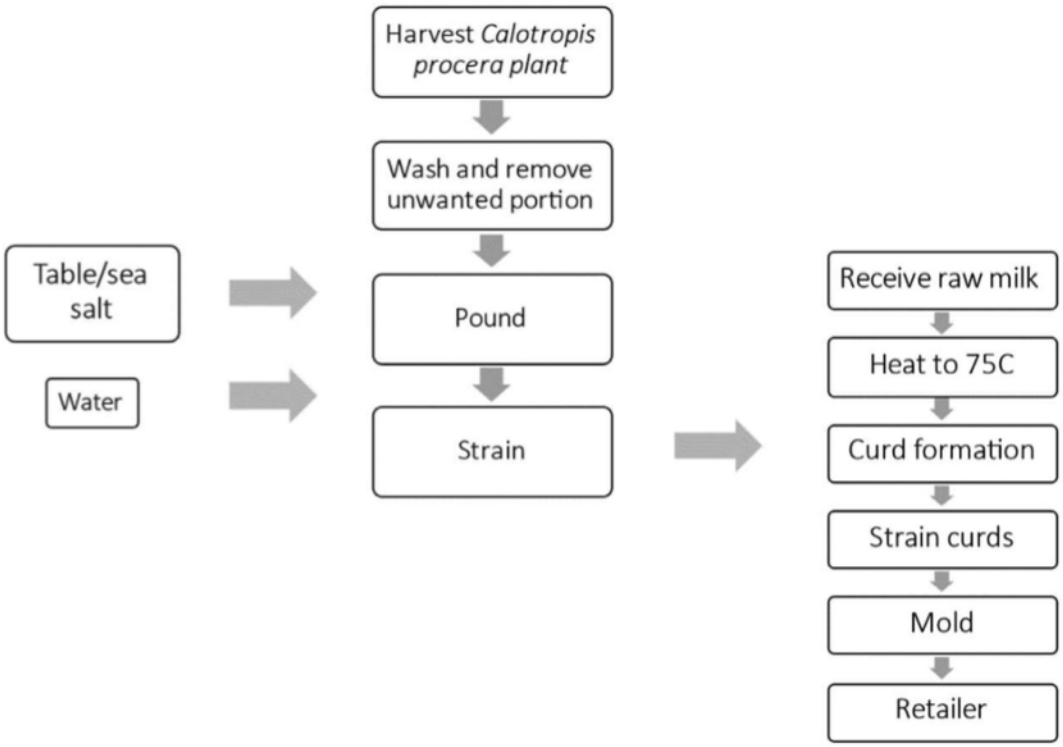

Fig. 1. Flow diagram of the cheese making process as reported.

supply chain or other controls. A total of thirteen (13) questions with close-ended choices were presented to processors. These questions were selected to suit their operational mode and levels. Table 5 shows the percentages of the responses that were recorded.

Most processors (>70%) reported that processing steps, such as inspecting raw materials before processing and controlling the boiling process, were critical to product quality. The majority also expressed that it was necessary as a processor to be familiar with hazards associated with cheese processing. However, none of the processors agreed that the temperature of the received milk was an indication of its quality.

Sanitation was directly observed and compared with the responses given by the processors. All the processors mentioned that it was essential to clean the area and equipment before and after processing, and they all complied, but the cleaning method was more thorough for some processors than others. More than 80% agreed that adulterants and hazards must be removed immediately when sighted during processing, but only about 40% performed these actions. All the processors were working under unsanitary environmental conditions that were likely to affect the product quality; however, less than 40% attested that this was true. The majority response to whether you must wash your hands when you leave the processing area for any reason was yes; however, none of the processors was observed performing this action. Among processors who responded no to the same question, the explanation was that cheese processing involved critical techniques, so it was better not to leave the processing area for any reason. Critical techniques in this instance referred to keenly observing the changes in cheese milk as soon as processing began to help regulate the heat source and prevent product defects. Most of the processors (73%) did not recognize the need for wearing clean clothes or covering their hair during processing. While it was observed that none of the processors had clothing that was dedicated to processing, all of them had hair covering in the form of scarves,

Table 5
Knowledge responses from cheese processors.[a]

Knowledge area	Number of responses; percentage in parenthesis			
	Reported		Observed	
	Yes	No	Yes	No
Hazards and process controls				
It is important to be familiar with common hazards associated with cheese processing	20 (76.92)	6 (23.08)		
The temperature of received milk must be measured as an indication of quality	0 (0.00)	26 (100.00)		
Received milk and other raw materials must be inspected for hazards and contaminants before use	26 (100.00)	0 (0.00)		
Curd boiling and straining must be controlled to prevent product defects	26 (100.00)	0 (0.00)		
Temperature control after cheese processing is critical for quality and safety	0 (0.00)	26 (100.00)		
Sanitation				
The sanitation of my processing environment can influence the quality of cheese	9 (34.61)	17 (65.38)	26 (100.00)	0 (0.00)
Before and after processing, I must clean my processing area and equipment	26 (100.00)	0 (0.00)	26 (100.00)	0 (0.00)
During processing I must wear clean clothes and cover my hair	7 (26.92)	19 (73.08)	0 (0.00)	26 (100.00)
During processing I must wash my hands if I leave the area or touch another human being or object or use the toilet	14 (53.85)	12 (46.15)	0 (0.00)	26 (100.00)
I must avoid processing when I am sick with a communicable disease	8 (30.77)	18 (69.23)		
During processing I must immediately remove hazards and adulterants when observed	22 (84.62)	4 (15.38)	9 (34.61)	17 (65.39)
Supply chain and other controls				
I should be aware of the types and signs of defects and spoilage that can occur with my products	26 (100.00)	0 (0.00)		
It is important to give specifications to raw material suppliers	0 (0.00)	26 (100.00)		

[a] Answers "No" include "Don't know."

turbans, or hijabs. Culturally, it is normal for some African and Muslim women to cover their hair during daily activities and outside the privacy of their homes. All the processors agreed that knowing about defects and causes of spoilage in cheese was critical; however, all the processors felt it was not in their place to provide specifications to their respective raw material suppliers. For most processors, the milk came from family farms and relatives. Others were supplied from neighborhood milk farms. None of them believed that what happened to the raw material before it got to them was a concern.

An open-ended question asking what conditions processors thought affected product quality, especially since the majority (65%) did not believe that environmental hygiene was a determining factor, yielded diverse responses (Table 5). Among the extrinsic factors, several of them listed changes in milk texture due to seasonal changes, with the rainy season bringing superior quality milk that was thicker and creamier. Others pointed to farming factors like cow feeding practices and whether the cow had calves that were lactating or not. The point on lactation was not milk quality but the quantity they would receive since they (processors) will compete with the calves for milk. Among the intrinsic factors, many mentioned that how well the cheese was cooked would determine the keeping quality. They explained that perfectly cooked cheese would have a firm curd that does not spoil quickly. The intensity of fire used was also pointed out. The explanation was that using high heat after adding the coagulant will produce weak curds or other product defects. Other factors that were commonly mentioned were the type of coagulant used. Most processors reported that using the stem of the *Calotropis* plant instead of the leaf gave better yield and a better-quality product. Some claimed the leaf caused color changes and bitterness. Some processors also mentioned that how long milk was kept before processing will affect the product quality; the longer it stays, the higher the defects. Such defects included total product failure. Upon asking how best the product could be kept, many processors responded that cooking the product well or boiling it in hot water on subsequent days was enough to make the product last between three and fourteen days (about two weeks) without refrigeration.

Overall, it was discovered that none of the participants had good knowledge about safety and hygiene during cheese processing. Very few had average knowledge, but the majority had poor knowledge of what was expected of them as processors (Fig. 2).

3.4. Attitudes

When the respondents were asked about their attitudes concerning processing, sanitation, and hygienic practices, overall, most of them had poor/incorrect beliefs (Fig. 2). All the processors believed that having some food safety plan and receiving training on hygiene and sanitation was important. The majority (80%) believed that knowing about food safety hazards, implementing controls for traditional processing, and knowing about product defects were important. Processors were asked if they believed they had to give suppliers and retailers certain specifications for how raw material or finished products may be handled to improve quality. Unfortunately, none of the processors believed that this was in their place to do. The majority (92%) also disagreed that a cold chain would enhance the shelf life of their products and that product quality was influenced by personal hygienic practices or the hygiene of the environment (Table 6).

Many processors did not believe that their products were unsafe and unsanitary and attributed this to their products being well cooked or sold fresh. When asked if they felt that consumers perceived their products were unsafe and unsanitary, there were

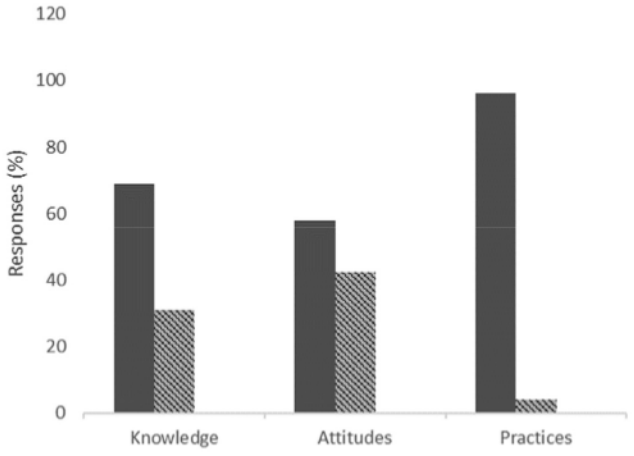

Fig. 2. Total knowledge, attitudes and practices ranks for traditional cheese processors: ■, poor; ▧, average; ■, good (no scores).

Table 6
Attitudes towards food safety and hygiene.

Statements	Number of responses; percentage in parenthesis		
	Agree	Disagree	Neutral
I believe that knowing about hazards is important	21 (80.77)	0 (0.00)	5 (19.23)
I believe that process controls can be implemented for traditional dairy products	21 (80.77)	1 (3.85)	4 (15.38)
I believe that suppliers and retailers must follow specifications to maintain product quality	0 (0.00)	26 (100.00)	0 (0.00)
I believe that training is important for traditional processors	26 (100)	0 (0.00)	0 (0.00)
I believe that processors must be concerned about product defects	20 (76.92)	0 (0.00)	6 (23.08)
I believe that if one product is defective or adulterated, the entire batch must be thrown out or reworked	0 (0.00)	14 (53.85)	12 (46.15)
I believe that maintaining a cold chain is important to extend shelf life	0 (0.00)	24 (92.31)	2 (7.69)
I believe that hygienic practices and environmental hygiene influence product quality	9 (34.62)	13 (50.00)	4 (15.38)
I believe that food safety plans will help with meeting standards	26 (100.00)	0 (0.00)	0 (0.00)
I believe that a food safety plan will help sell beyond informal markets	0 (0.00)	0 (0.00)	26 (100.00)

divided answers. Most of them said they would understand if some felt that way because they believe that many of them do not know how the cheese was processed, and many processors and retailers work in unsanitary conditions. A few other processors said that they believed consumers looked out for visual cues like color, shape, and size of the product before buying and were therefore not genuinely concerned about sanitation. Upon asking if they believed that the traditional cheese products were better than modern ones, the consensus was yes because they believed traditional products were tastier, healthier, more nutritious and did not contain artificial additives. Many also attested they had never seen or tried modern cheese products but felt their products were better. When asked if they believed that they could sell their products in formal markets like supermarkets and gas stations if their food safety and hygiene knowledge were improved, they were all neutral, with some reluctantly saying that it was possible. While some expressed that they did not know if their products had a place in the formal marketing outlets, others were nonchalant with the simple explanation that they had never tried and would not know. Some said they had never ventured outside what they knew, and others expressed that it might be an avenue for a better price. A few, however, expressed doubt that traditional cheese had a place in formal marketing outlets.

3.5. Practices

Answers for practices were both self-reported and confirmed with observations (Table 7). There were no differences between self-reported answers and observations made on site. All processors conducted some form of screening for raw milk prior to processing. Most (92%) reported straining the milk to remove residual dirt, hair, and other particles. Very few reported tastings or smelling the milk or using other physical characteristics to determine if it was sound for processing. None of them used milk that had undergone microbial or physicochemical testing. All processors processed milk within an hour after receipt, insisting that it was best to begin immediately the milk arrived. Most reported that the milk would either go bad or not form cheese curds if kept for extended periods prior to processing.

Table 7
Self-reported and observed practices of processors ranked as poor, good, or best.

Self-reported practices	Rank	n (%)
Milk handling		
Strain	good	24 (92.31)
Visual exam	good	1 (3.85)
Taste and smell	good	1 (3.85)
Length of time milk is kept prior to processing		
Process immediately milk arrives	best	26 (100)
How to properly regulate cooking temperature		
Observe physical signs and dip hand in cooking cheese	poor	23 (88.46)
Observe without hand dipping	good	2 (7.69)
Fetch sample and dip finger	good	1 (3.85)
Treatment given to the finished product		
Drain for 3 min and distribute	poor	26 (100)
Instructions given for handling and consumption		
None	poor	23 (88.46)
Refrigerate	best	2 (7.69)
Will provide when asked	poor	1 (3.85)

Since the cheese making process requires careful temperature regulation, it was essential to assess how this is done. In the absence of specific temperature measuring tools, most processors resorted to visual cues to indicate when the heat source should be regulated to aid the curd formation process. While most (88%) of the processors relied on their experience, many of them confirmed by dipping their fingers directly into the pot to check the temperature of the milk. A couple of them reported taking a small sample out of the pot to check the temperature. Upon completing the process, the processors gave no further treatment to cheese. Again, many processors did not feel it was essential to tell retailers or consumers how to safely handle or consume the products. Very few of them recommended refrigeration as a preservation option, but many said they felt that people already knew how to handle the product.

Most processors also produced cheese for immediate and external retailers, suppliers, and consumers. The mode of transportation was often via head porters or motorbikes. Very rarely, processors use public transportation modes like commercial buses to deliver products.

4. Discussion

4.1. Knowledge, attitudes, and practices of processors regarding food safety and hygiene

A key finding of this study was that most cheese processors receive all prior knowledge regarding processing cheese from predecessors in their family only. Therefore, knowledge about hazards and process controls, sanitation, and supply chain controls on the impact of safe and hygienic processing is limited and, in some cases, inaccurate. For instance, most expressed the view that the milk came directly from dairy farms primarily within, and sometimes external to, their processing vicinity, and they had never considered measuring the temperature of the milk they received. For those who lived near kraals, milk delivery was often done by male family members or neighbors who tended to the cows. For milk received from the immediate vicinity, it was often transported in plastic gallons and buckets on foot or motorcycles. There were also no measures to ensure milk was cooled via transportation. While milk remains sterile in the udder, it is essential to note that

the storage temperature after milking plays a considerable role in the microbial proliferation of microorganisms of public health significance and the risk of illness (Crotta, Paterlini, Rizzi, & Guitian, 2016; Raza & Kim, 2018). The code of hygienic products for milk and milk products (CAC/RCP 57–2004; FAO, 2009) also recommends that harvested milk must be cooled and maintained at a temperature that ensures that microbial growth is limited.

In terms of sanitation controls, most processors lacked the knowledge that wearing clean clothes, hand washing, and processing in a clean environment could directly affect product quality outcomes. Observations revealed that many processors removed adulterants without much thought to re-contaminating the products at other processing steps or not correcting their actions, even after reporting they did. Corrections observed included directly dipping dirty fingers into milk to remove particles and directly picking particles out of cheese curds with unclean hands. According to Owusu-Kwarteng et al. (2020), during traditional milk processing, the poor sanitation of the processing environment and poor personal hygiene of the processors can cause direct contamination of processed products with pathogenic microorganisms. A comparative study conducted by Schoder, Maichin, Lema, and Laffa (2013) on the hygiene of products from milk processors in Tanzania revealed that processing under unhygienic conditions was merely due to no understanding of hygiene and no motivation to maintain hygienic conditions. This lack of knowledge was further positively correlated with the subsequent discovery of higher-than-normal counts for total bacteria counts, coliforms and *Escherichia coli* in many samples from processing plants where poor worker hygiene was prevalent.

Another important finding of this study was that, although cheese processors are not the endpoint in the local cheese supply chain, they did not know that providing specifications to actors upstream and downstream could play a role in product quality. Analysis of dairy supply chain features likely to create unsafe supply in Pakistan by Hassan et al. (2021) revealed that safety failure factors could be because of farm-related or retailer-related factors such as inadequate health conditions of farmers, mediocre quality controls in milk production, unhygienic transportation of dairy products to retail and the subsequent sale of unsafe products. A preliminary analysis on smallholder dairy production in Indonesia by Daud, Putro, and Basri (2015) also showed that milk handling and transportation practices constitute a chunk of risks of varying nature in the supply chain. There are not enough safety features in place for smallholder operations, or in this context for the actors, to present risk-minimizing behavior to ensure safe supply to downstream actors.

Table 8 shows some analytical data measured during processing as indicators of microbial survival. Despite the risk-enhancing behaviors discussed in this study, raw milk at reception was within acceptable pH limits. Milk was further boiled to temperatures higher than legally recommended pasteurization temperatures. At the end of production, the temperature of Wagashi cheese could still permit the survival of bacterial spore formers however heat resistance is highly dependent on the optimum pH for their survival (USFDA, 2018). It must be noted that the limited scope of the study did not consider other risk factors during milk harvesting and retail.

A positive outcome of this study was that most of the processors agreed that specific interventions were necessary. These included the need for training, having a food safety plan, improving controls in traditional processing and being familiar with common hazards and product defects. However, an overall analysis of all questions revealed that attitudes towards food safety and hygiene were not optimal for all processors. A chunk of the suboptimal attitudes was remarkably like knowledge analysis, giving specifications to retailers, hygienic practices, and environmental conditions. An interesting finding was the processors' negative attitudes towards the role a cold chain may play in cheese quality. Notably, while some of the processors had access to electricity, they had all learned processing from people who had no access to electricity. Therefore, a cold chain was not a factor to consider during operations. It is also highlighted that no temperature control was involved for raw products (milk) or the finished product (cheese). While soft

Table 8
Inferential analytical parameters for indices of possible microbial survival.[a]

Process variable	Location	Inferential analytical parameter accessed		Reference values for microbial survival	Reference
		pH	Temperature (°C)		
Milk reception	Ab	6.7 ± 0.0		pH < 6.5–6.8	EAS (2006); Gwandu et al. (2018); Marouf & Elmhal (2017)
	Ak	6.5 ± 0.2			
	Ag	6.8 ± 0.2			
	Do	6.8 ± 0.1			
	Sa	6.7 ± 0.0			
	Tu	6.4 ± 0.1			
Initial heating of milk (10 min)	Ab		70 ± 5	<69 °C for 30 min (vat pasteurization)	IDFA (2022)
	Ak		75 ± 5		
	Ag		82 ± 5		
	Do		75 ± 5		
	Sa		75 ± 5		
	Tu		78 ± 5		
20 min into cooking process	Ab	6.5 ± 0.0	90 ± 10	<69 °C for 30 min (vat pasteurization)	IDFA (2022)
	Ak	6.3 ± 0.2	85 ± 7		
	Ag	6.2 ± 0.2	90 ± 5		
	Do	6.2 ± 0.1	90 ± 8		
	Sa	6.5 ± 0.0	85 ± 10		
	Tu	6.2 ± 0.1	85 ± 5		
End of process (final product)	Ab	6.71 ± 0.03	80 ± 5	pH ~ 5.5–7	Aboudoulaye & Kaya (2020); Anihouvi & Kesenkaş (2022)
	Ak	6.69 ± 0.10	75 ± 3		
	Ag	6.70 ± 0.00	82 ± 5		
	Do	6.50 ± 0.00	83 ± 8		
	Sa	6.71 ± 0.02	75 ± 5		
	Tu	6.50 ± 0.00	82 ± 5		

[a] Abbreviations are: Ab, Aveyime-Battor; Ak, Akuse; Ag, Agomeda; Do, Dodowa; Sa, Sasaabi; Tu, Tulaku.

unripened cheese also presents a high-risk factor for microbial growth, we must remember that this factor was also of little concern because the processors were not the endpoint in the supply chain.

Location type did not influence processor attitudes (Table 9). This result was likely because the interviewed processors lived in low-income areas and had the same operational and marketing strategy through informal markets. Informal markets usually have lower standards and poor regulation, so requirements for quality are not as enhanced (Staal et al., 2008). It is also worth noting that the consumer type has long driven the marketing trends in sub-Saharan Africa (Aschemann-Witzel, Gantriis, Fraga, & Perez-Cueto, 2021; Walshe, Grindle, & Bachmann, 1991) and therefore, the considerations that processors will be willing to put in place to improve hygiene and safety perceptions. Other indicators of socio-economic status of the processors, such as whether they had a health certificate, electricity, or a smartphone or not, also did not influence their attitudes (Table 9). Age group and education status, however, were positively correlated with attitudes (Table 9). In assessing the influence of the attitudes and behavior of milkers, in the Antioquia province of Colombia, on the sanitary quality of milk, Múnera-Bedoya, Cassoli, Machado, and Cerón-Muñoz (2017) found that the presence of learning opportunities and younger ages of milkers were among factors that were positively correlated with excellent hygienic and sanitary parameters of milk. Another study conducted by Paraffin, Zindove, and Chimonyo (2018), for both small- and large-scale dairy farmers in Zimbabwe revealed that age affected the perception of quality, as farmers older than 30 years were more likely to understand that hygiene will influence milk quality.

There was not enough statistical evidence to suggest correlations between any of the processor characteristics and self-reported practices (Table 10). The study, however, revealed that all processors were engaged in at least one best practice where received milk was not stored for longer than an hour prior to processing. This practice was gained solely through experience because many processors explained that several things could go wrong if milk was stored. Among these were milk spoilage, low yield, and product failure. A training program for the small-scale dairy sector in Kenya by the Food and Agricultural Organization (FAO, 2013) recommended that milk be transported fast, efficiently and processed quickly to reduce the potential for microbial growth.

Prior to processing, the processors reported and were observed in many instances straining the milk to get rid of physical hazards like animal hair, houseflies, and other debris. While this is good practice, other well-established tests for milk quality were absent.

Table 9
P-values from Fisher's exact test.[a]

Processor characteristic	Knowledge	Attitudes	Practices
Age group	0.164	0.004	0.595
Education status	0.064*	0.035*	0.512*
Location type	0.185	0.339	0.244
Health certificate	0.220	0.364	0.713
Electricity	0.671	0.597	0.497
Smartphone	0.149	0.391	0.345

[a] An asterisk (*) indicates performed by Man Whitney U test. Numbers are significant at $p < 0.05$.

Table 10
Pearson's correlation among knowledge, attitudes, and practices (*p*-values). [a]

	Attitude	Practices
Knowledge	<0.001	0.126
Attitude		0.234

[a] There is a statistically significant association if $p < 0.05$.

Many explained that the milk was received fresh from the kraal, and therefore, there was little possibility that the milk would go bad. The milk was not received via cooperatives or commingled milk sources where they may have undergone bacteriological testing. Processors also did not report conducting any physico-chemical tests on the milk received to ensure it was adequate for processing. Even basic organoleptic tests like observing the color, smell and taste were not conducted.

4.2. What did processors know and believe?

The findings of this study uncovered that, regardless of the status of knowledge, attitudes, and practices regarding food safety and hygiene during processing, traditional cheese processors were knowledgeable on internal and external processing conditions that may affect product quality, contrary to popular opinion. The open-ended question, "What affects the quality of wagashi (cheese)" allowed processors to express diverse views on what they knew, believed, and practiced (Table 11).

Processors explained what processing factors they believed would influence the quality of cheese. Among them was the regulation of heat. Temperature regulation during the cooking process is a critical step, the lack of which will lead to critical product defects like poor curd formation or total product failure. The method of dipping a finger directly into cooking cheese, as practiced, could be a source of contaminants. However, it is worthy to note in the book "Life of Cheese", Paxson (2013) details how traditional American cheese makers have similarly drawn on past experiences and generational knowledge, and in the absence of modern equipment, trusting hands over thermometers successfully crafted some of consumers' most-loved cheese: "When the cheese is ready for reduced fire, I can tell by just looking at it. Some water collects on the surface" (processor interview).

Processors also highlighted other factors contributing to product defects and total product failure. Among them included keeping the milk for longer than a minimum of four (4) hours before processing. Some processors explained how this would lead to yogurt production instead of cheese: "If you leave the milk standing, the product will become yogurt, not cheese" (processor interview). Because fresh milk is an optimum medium for microbial growth, it is common for spontaneous fermentation to occur. Indeed, spontaneous fermentation is harnessed in the production of yogurt-type traditional dairy products. Research has shown the involvement of species from the *Lactobacillus, Lactococcus, Acetobacter, Streptococcus* genera and some yeast and mold are often involved in these fermentation processes (Akabanda, Owusu-Kwarteng, Tano-Debrah, Parkouda, & Jespersen, 2014; Groenenboom et al., 2019; Nduko, Matofari, Nandi, & Sichangi, 2017).

Regarding curd integrity, processors mentioned factors such as the non-traditional addition of milk powder, thoroughly cooking the curd and refrigeration of the final product. More standardized cheeses often have well-documented process control points that cater to the concerns raised. Although there is no literature citing the investigation of these factors on curd integrity of this specific fresh unripened cheese type, investigations have been carried out in other cheese categories with varying results. For example, Rehman, Farkye, Considine, Schaffner, and Drake (2003) successfully used whole milk standardized with dry milk protein concentrates to produce reduced-fat cheddar cheese. This technique successfully increased the total solids content while reducing whey volume, alluding to the increased firmness of the cheese curds. In industrial settings, physicochemical indices like titratable acidity (TA) and pH monitor the cheese cooking process. Hill and Ferrer (2021) note that TA will often vary with milk composition, while pH indicates acid development throughout the cheese making

Table 11
Processing and non-processing factors that affect cheese quality according to traditional processors.

Factor	Perceived consequences
Processing related factors	
Keeping milk longer than 4–6 h prior to processing	Product failure
Re-constituting raw milk with powdered milk	Weakens the cheese curd
Poor regulation of heat	General product defects
The use of *Calotropis* leaves instead of stem	Causes bitterness
Cooking thoroughly	Strengthens cheese curd
Refrigeration	Disintegrates cheese curd
Excessive salt	Decreases yield
Re-boiling as a preservation method	Curds shrink in size, but increase in density
Non- processing related factors	
Season	Variations in season change milk quality
Lactating cows	Poor milk quality
Poorly fed cows	Poor milk quality
Distance from farm to the processing site	Delaying milk arrival changes taste

process and can be used to control pathogenic and spoilage microbes. On the contrary, in smallholder non-formal settings, the technical knowhow is often absent (Lindahl, Deka, Asse, Lapar, & Grace, 2018; Omore et al., 2009).

Another important finding of the survey was how the final product is handled after processing before it goes to the next actor in the supply chain (usually retailers or food services). Observations included allowing cheese curds to form and drain in perforated cane basket molds for a maximum of three (3) minutes, during which there is a quick flip, and then the cheese is allowed to sit in a bowl while the excess whey pooled around it. There was no indication of how long cheese remained in that condition during transportation. However, re-introducing moisture after attempting to drain the product may or may not affect the cheese's physicochemical properties. This possibility is being investigated in subsequent studies.

Non-processing related factors that processors believed could influence cheese quality were related to season, some animal farming practices and the distance from the farm to the processing site. Processors explained that season and animal rearing practices often affected the creaminess of the milk and, therefore, the yield. Specifically, they received more watery milk during the dry season and when an animal had younger calves. Changes in milk composition during seasonal and gestational -related changes are well documented in the literature (Gillah, Kifaro, & Madsen, 2014; Li, Ye, & Singh, 2019; Lin, O'Mahony, Kelly, & Guinee, 2017; Roessler, Mpouam, & Schlecht, 2019). However, processors also showed concern in changes to the taste of fresh milk received if the distance from the farm was too far or a delay in transporting the milk to the processing site occurred due to uncontrollable factors like poor weather, unavailable transportation, or other factors. In such cases, the milk was still used, but the possibility of product failure was high, as previously explained.

5. Conclusions

Overall, this study proved that the hypothesis was confirmed. The results showed that most of the cheese processors in Southern Ghana who were interviewed had poor knowledge, attitudes and practices regarding food safety and hygiene during traditional cheese processing. Specifically, the processors lacked knowledge in: setting up the processing area; sanitation protocols before, during and after processing; process controls that may prevent the introduction of adulterants and enhance overall product quality; temperature control after processing. They also had poor attitudes regarding specifications for supply and retail, the influence of the production environment on product quality, and expanding their market reach. Best practices that could be improved include inspecting all raw material before processing, regulating cooking temperature during processing, better handling finished cheese curds, and improved preparation for transportation. There was some statistical evidence to suggest an association between age and education status with attitudes. There was, however, not enough evidence to suggest that there was an association between any other demographic or processor characteristics and either knowledge, attitudes, or practices. Overall, there was no correlation between practices and attitudes or knowledge. Attitudes and knowledge, however, were associated.

Processors agreed that training is needed to increase their knowledge, attitudes, and practices. Although several training programs exist, these processors do not have access to technical information. There is the need to create a training program suited to their level of understanding and needs.

In addition, since the product moves to another actor in the supply chain, there is a need to investigate appropriate processing and post-processing techniques to reduce whey pooling while maintaining pH in the absence of cold storage. This technique is vital to minimize the potential for recontamination and spoilage. The technique may also be more cost-effective to processors who reported having to boil remaining pieces of cheese daily and ensure that retailers receive a safe product. Such procedures can be introduced to the traditional processors to gauge their feasibility.

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Credit author statement

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Declaration of competing interest

None.

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