

**USING LOW TECHNOLOGY TO IMPROVE THE SAFETY OF
INFORMAL-VENDED *BRUKINA*– A FERMENTED MILK AND MILLET
SMOOTHIE IN GHANA**

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ABSTRACT

Brukina, a fermented milk, and millet smoothie, is a popular indigenous beverage in Ghana. Its production is dominated within the Northern regions of Ghana. *Brukina* is considered as a complete meal due to its high nutrient and energy density. There are, however, quality and safety gaps associated with the traditional production of *brukina* which limits patronage, shelf-life and nutritional benefits. This study evaluated the microbiological quality at selected *brukina* production steps and the retailed *brukina* drink. Samples were taken along the production chain from four major traditional *brukina* producers within the Greater Accra region and analysed for the total viable count, total coliforms, *Staphylococcus aureus*, yeasts and moulds, and pH. The mean microbial concentrations for traditionally produced and marketed products were 7.48 Log CFU/mL for total viable counts, 2.91 Log CFU/mL for total coliforms, 4.68 Log CFU/mL for *S. aureus* and 5.25 Log CFU/mL for yeasts and moulds. Mean pH of the finished product on the market was 4.35. The microbial counts along the production chain were generally high, revealing poor hygienic handling and need for process optimization. Data generated from microbiological analyses of commercial *brukina*, food safety audits from previous studies and CODEX code of hygienic practices were used as guidelines to optimize the traditional process operations and develop a Standard Operating Procedure (SOP) for hygienic production of traditional *brukina*. Implementation of the SOP in a controlled environment reduced the total count by 4.28 Log CFU/mL at $P=0.000$ and total coliforms by 3.63 Log CFU/mL at $P=0.035$ at all the tested production steps. The optimized *brukina* had a mean total count of 4.06 Log CFU/mL and undetectable levels of total coliforms and *S. aureus*. Critical control steps in traditional production operations were identified as the steaming of milled and agglomerated millet and milk pasteurization. The SOP developed provides a low technology solution to improve quality and safety of traditional *brukina*.

Key words: *Brukina*, Standard Operating Procedures (SOP), microbiological quality, hygiene, dairy



INTRODUCTION

The informal food sector in many developing countries plays a fundamental role in the supply of nutritious and convenient foods that meet the needs of a vast majority of the populace [1]. Although this sector has many benefits, especially its contribution to food security, it also faces serious challenges with food safety [2]. In Ghana, the informal food sector has proliferated over the past three decades in peri-urban and urban centres. They provide avenues for employment for urban migrators and dwellers who usually do not find other lucrative employment opportunities [1]. The demand for convenient, low-cost foods is high and such businesses require little start-up capital and no formal education, making it an easy avenue for employment creation. Food safety is not a priority for consumers that patronize such businesses. Moreover, the business actors themselves have very little resources for business expansion and rarely adopt best practices following food safety interventions [3]. In order to improve the food safety situation in Ghana and other developing countries, there is the need to develop low-technology solutions that can be easily integrated into existing production operations to encourage adoption and sustainable implementation.

One such informal food sector that is rapidly growing in Ghana is the dairy cottage industry that produces among others the popular *Brukina* beverage. *Brukina* is a fermented milk and millet smoothie. It is produced by mixing milled and steam cooked millet with fermented cow milk and sugar [4]. Milk is usually fermented spontaneously and in some cases, by back slopping with leftover fermented milk. *Brukina* gets its name from its country of origin, Burkina Faso, a neighbouring country to Ghana where the product is called *dèguè* [5].

Brukina has gained popularity in Ghana and is considered one of the most successful indigenous beverages in the country. It competes well with yoghurt and other common local beverages such as *nunu*, *asana*, *ice-kenkey* and *sobolo* [6]. The usual packaging for *brukina* in Ghana is polyethylene terephthalate (PET) bottles although some sedentary retailers serve it in wooden bowls (*calabash*) or plastic bowls. Informal small-scale producers from the Northern regions of Ghana, who are specialized in dairy businesses, dominate production of *brukina*. However, owing to its popularity and demand, several other stakeholders from different parts of the country are currently engaged in its production and sales [5].

Production of *brukina* usually occurs under uncontrolled and unstandardized conditions which lead to high variability in microbiological quality and safety. A study of street-vended *brukina* indicated the presence of *E. coli* O157:H7 and *Staphylococcus aureus* [7]. Unsanitary production environment, contaminated water used in cleaning food contact surfaces, improper personal hygienic practices of producers, and use of inadequately washed utensils were gaps resulting in pre-production, in-production and post-production microbial contamination of *brukina* [5]. All of these audit findings point to sanitation and hygiene deficits in production operations.

Milk is a high-risk product, providing optimal conditions for bacterial proliferation when stored under ambient temperature [8]. Therefore, it is important to control milk



operations throughout the value chain to ensure products are safe, nutritious and meet consumer sensory requirements. Quality control based on quality specifications, production guidelines, and safety standards are essential to meet the regulatory requirements of the sale of wholesome foods [9]. Unfortunately, there are no such standardized operational guidelines to inform traditional *brukina* producers. This study sought to develop a simplified, integrated and verified hygienic standard operating procedure (SOP) by optimising existing production operations used in the informal sector to improve hygienic and sanitary production operations and safety of traditionally produced *brukina*.

MATERIALS AND METHODS

Study design

The study was in three phases: 1) Assessment of the microbiological quality at multiple production steps during *brukina* production; 2) Development of a hygienic SOP for traditional *brukina* production, and 3) Verification of the SOP.

In the first phase, major *brukina* producers were identified in four localities within the Greater Accra region. These commercial producers produce packaged *brukina* in relatively large quantities for distribution to multiple vendors who retail the products in and around the Greater Accra region of Ghana. The producers selected for the study were located in Ashiaman, Mataheko, Accra New-Town, and Dansoman, all of which are suburbs in the Greater Accra. In each locality, one producer was selected based on the volume of production and willingness to participate in the study. Samples of soaked millet, milled millet, millet agglomerates, steam cooked millet, boiled milk, fermented milk, and the finished *brukina* product were taken along the production chain at each production site (Figure 1). Two rounds of sampling at the selected stages of *brukina* processing were conducted at each of the four selected production sites. At each of the selected sampling stage, 50g of samples was aseptically transferred into labeled sterile containers, stored in ice-chests containing ice packs and transported to the Microbiology Research Laboratory of the Department of Nutrition and Food Science for bacteriological and physicochemical analyses.

For the second phase, information on the production steps involved in the traditional production of *brukina* was documented from the four *brukina* producers through interviews and direct observation. Based on their production methods, previous process optimization studies, food safety audit findings, and guidelines of the CODEX code of hygienic practices [10], an SOP was developed for hygienic production of traditional *brukina*.



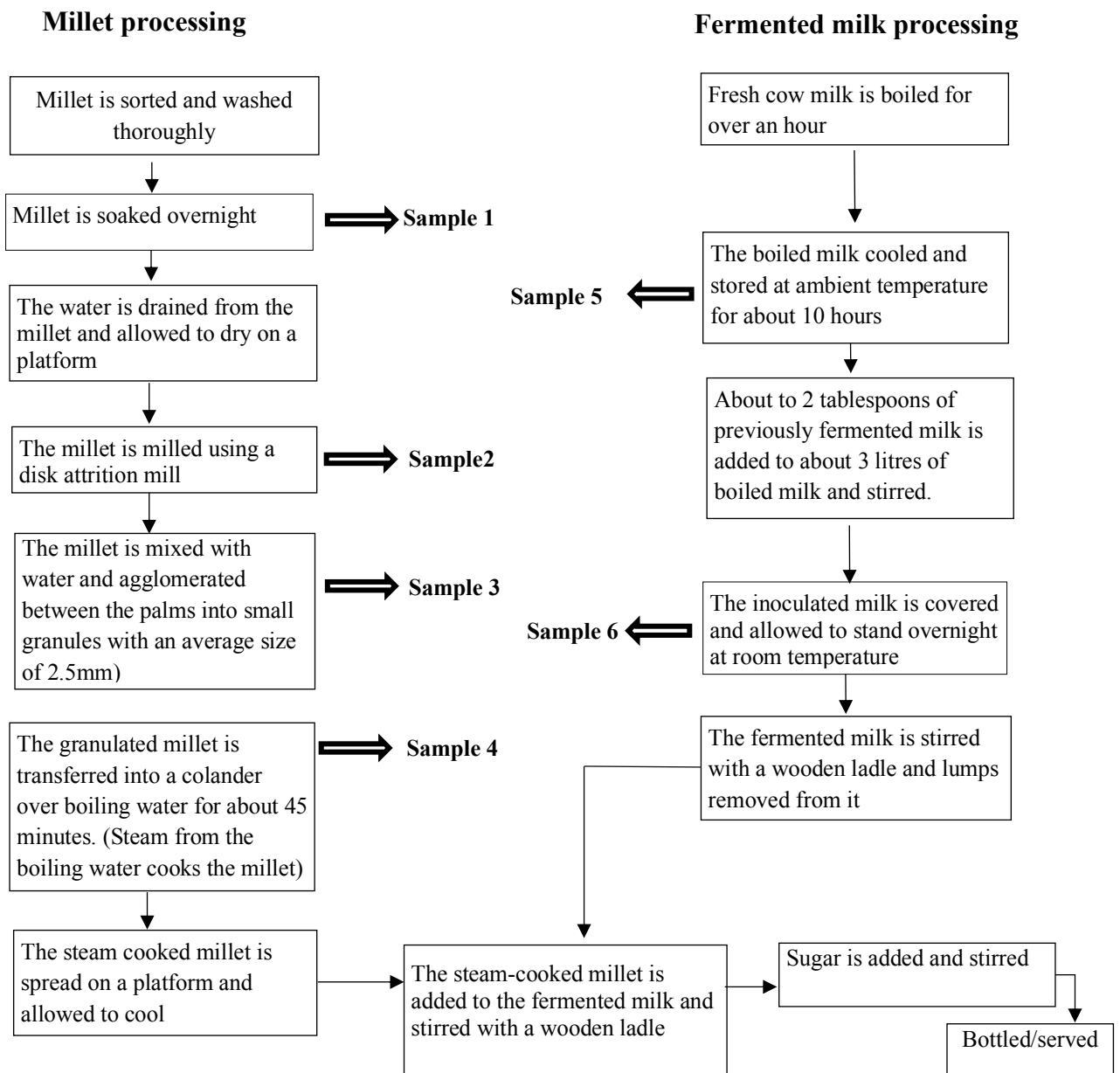


Figure 1: Traditional processing steps for *brukina* production depicting sampling points (numbered 1 to 6)

The third phase of the study involved verification of the SOP by repeating the optimized hygienic processes and sampling soaked millet, milled millet, millet agglomerates, steam cooked millet, boiled milk, fermented milk and finished *brukina* product for microbial and physicochemical tests.

Microbiological quality assessment

Samples of soaked millet, milled millet, millet agglomerates, steam cooked millet, fermented milk and finished *brukina* products were analysed for Total Viable Bacteria,

total coliforms, Lactic Acid Bacteria (LAB) count, *S. aureus* count, and Yeast and Mould count.

Methylene blue reductase test was performed on boiled/pasteurized milk samples to assess pasteurization efficiency.

Sample preparation

Ten grams of each of millet, boiled and cooled milk, fermented milk, and *brukina* samples were weighed aseptically into a sterile stomacher bag; 90ml of sterilized 0.1% buffered peptone water (Oxoid CM0009) was added and homogenized for one minute using Stomacher® 400 Circulator. Serial dilutions were prepared from homogenates [11].

Bacteriological analyses

Aerobic plate count was determined by pour plating on Plate Count Agar (PCA, Oxoid CM0325). Inoculated PCA plates were incubated at 37°C for 18-24 hours. Lactic Acid Bacteria counts were determined by pour plate overlay with de Man Rogosa and Sharpe Agar (MRS, Oxoid CM036) and incubated for 24 hours at 37°C. Yeast and Mould were enumerated by pour plating on Malt Extract Agar (MEA, Oxoid CM0059) and incubated at 25°C for five days. Total coliforms counts were determined by pour plate overlay using Violet Red Bile Glucose agar (VRBG, Oxoid CM0485) and incubated for 18-24 hours at 37°C. *S. aureus* was enumerated by spread plating on Mannitol Salt Agar (MSA, Oxoid CM0085) and incubated at 37°C for 24-48 hours and confirmed with coagulase agglutination using human blood plasma.

Methylene blue reductase test

Methylene blue reductase test was conducted as described [12].

The milk quality was classified as follows:

- Reduction within 30 minutes — very poor milk quality.
- Reduction within 1.5 hours to 2 hours — poor milk quality.
- Reduction within 2-6 hours — fair quality milk.
- Reduction within 6-8 hours — good quality milk

pH determination

The pH of milk samples and homogenate ground millet was determined using a Mettler-Toledo pH meter.

Development of SOP for hygienic processing of *brukina*

The SOP developed for traditional *brukina* production is presented in Appendix 1. The SOP integrated essential sanitary practices required for hygienic production of *brukina* alongside quality control measurements for consistent processing of a good quality product, and critical control points to ensure a safe product. The SOPs addressed unsanitary processing gaps identified from previous studies using Codex code of hygienic practices [10] as guidelines. These are: effective cleaning, sanitization of equipment and food contact surfaces, maintenance of personal and processing hygiene, simple quality control checks and temperature-time monitoring at critical control points. The critical control points were the “kill-steps” along the production chain and were considered important to ensure the safety of the product.

Statistical analysis

One-way Analysis of Variance (ANOVA) was used to determine the statistical differences between mean pH and mean microbial concentration at different production steps. Independent samples T-test was used to compare the significance of differences between microbial concentration from commercial producers and optimized process. All statistical analyses were conducted using IBM® SPSS® version 22 and Microsoft Excel 2013.

RESULTS AND DISCUSSION

Traditional production of *brukina*

Production steps involved in traditional processing of *brukina* is presented in Figure 1. It is a two-stage process: millet preparation and milk fermentation. The millet preparation involved uncontrolled overnight fermentation of washed millet, milling at commercial facilities in traditional markets, agglomeration with bare hands, steam cooking for an average of 45 minutes and cooling uncovered at ambient temperatures. The milk fermentation began with the boiling of cow's milk in cast iron pots for an average of 60 minutes. Heat-treated milk was then cooled and allowed to ferment spontaneously or back slopped with a previous batch of fermented milk. Fermentation occurred overnight at ambient temperature. When milk was set, it was homogenized with a wooden ladle and mixed with millet and sugar. The finished product was then ready to be served at milk bars in traditional markets or packaged in PET bottles for retail, typically through street vending.

Bacteriological quality and changes in pH during traditional *brukina* production

The bacteriological quality of traditionally produced *brukina* along the production chain is shown in Table 1. Microbial concentrations in traditionally produced and marketed *brukina* were generally high. *S. aureus* count exceeded the microbiological limit (1×10^3 CFU/ml) for cultured dairy products as specified in the Ghana standards GS955:2013. The study identified milling of fermented millet as a risk factor in the traditional production of *brukina*. The milled millet had significantly higher counts of aerobic bacteria, total coliforms, yeasts and moulds, and *S. aureus* (Table 1). *S. aureus*, in particular, had an average of 4 log CFU/g increase in counts after milling. The *brukina* producers interviewed admitted to using commercial mills at the traditional markets for milling their soaked millet. These commercial mills were available for the public to mill any food raw material at a fee. It is known that the commercial mills at the open markets do not clean their equipment in between milling different batches of food items. The commercial millers also tend to queue items to be milled at ambient temperatures in the milling environment until the service can be rendered to the client. All of these contribute to cross-contamination and the proliferation of microbes during the milling process [13].

Steam cooking significantly reduced aerobic bacteria and coliform concentrations in millet for all eight production batches. However, there was no significant reduction in yeast and moulds and *S. aureus* counts, although there was an average of about 2 Log cfu/g reduction in counts (Table 1). Steam cooking was insufficient to eliminate microbial populations in millet. On average, millet is steam cooked for 45 minutes. The



heat treatment was insufficient to kill all the microbes present within the cooking time due to the high initial microbial concentration in milled millet, large quantities of millet steamed in a batch, and inefficient heat transfer of top packed millet as a result of steaming large quantities at a time. Furthermore, it was common practice not to cover millet tightly during steam cooking. This practice prevents containment of heat during steam cooking. It is, therefore, hypothesised that persistence of microorganisms in steam-cooked millet is as a result of sub-lethal heat dose provided to the top layers of millet during steam cooking, and injury repair and subsequent proliferation of survived microbes during cooling of millet [14].

Boiling temperatures and duration used by the commercial processors were effective in ensuring the microbiological quality of the milk prior to fermentation (Table 2). Thus the presence of total coliforms, *S. aureus* and yeast and moulds in the fermented milk was due to post-processing contamination from unhygienic food handling practices. It was observed that producers did not usually wash and sanitize equipment and hands before and during production. This may have caused the post-processing contamination of the boiled milk leading to the presence of coliforms and *S. aureus* in the fermented milk. Similar findings have been reported by some studies on fermented milk [7, 14, 15, 16, 17, 18]. Although the pH of the fermented milk was fairly acidic (4.35 ± 0.00), some of the microorganisms still persisted. The increase in microbial concentrations in *brukina* was due to the presence of microbes in the cooled millet that was added to the fermented milk. Poor quality of sugar could also compromise the microbiological quality of *brukina*. Higher microbial concentrations have been reported in street-vended *brukina* [19]. The average pH of *brukina* was 4.35, which allows microbial proliferation, including microbial fermenters, during retail. There is, therefore, a need to improve traditional production and retail operations to ensure good quality *brukina* that is also safe for nourishment.

Verification of SOP for hygienic production of traditional *brukina*

Verification of the SOP (Figure 2) in a laboratory setting showed drastic reductions in microbial concentrations of *brukina*. The verification results are summarized in Table 3. Whereas some operations in the optimized SOP such as overnight fermentation of millet and fermentation of pasteurized milk remained uncontrolled, as in the traditional process, the sanitary environment, hygienic handling and efficient cooking of the product ensured a good microbiological quality of *brukina* produced with the SOP (Table 3).

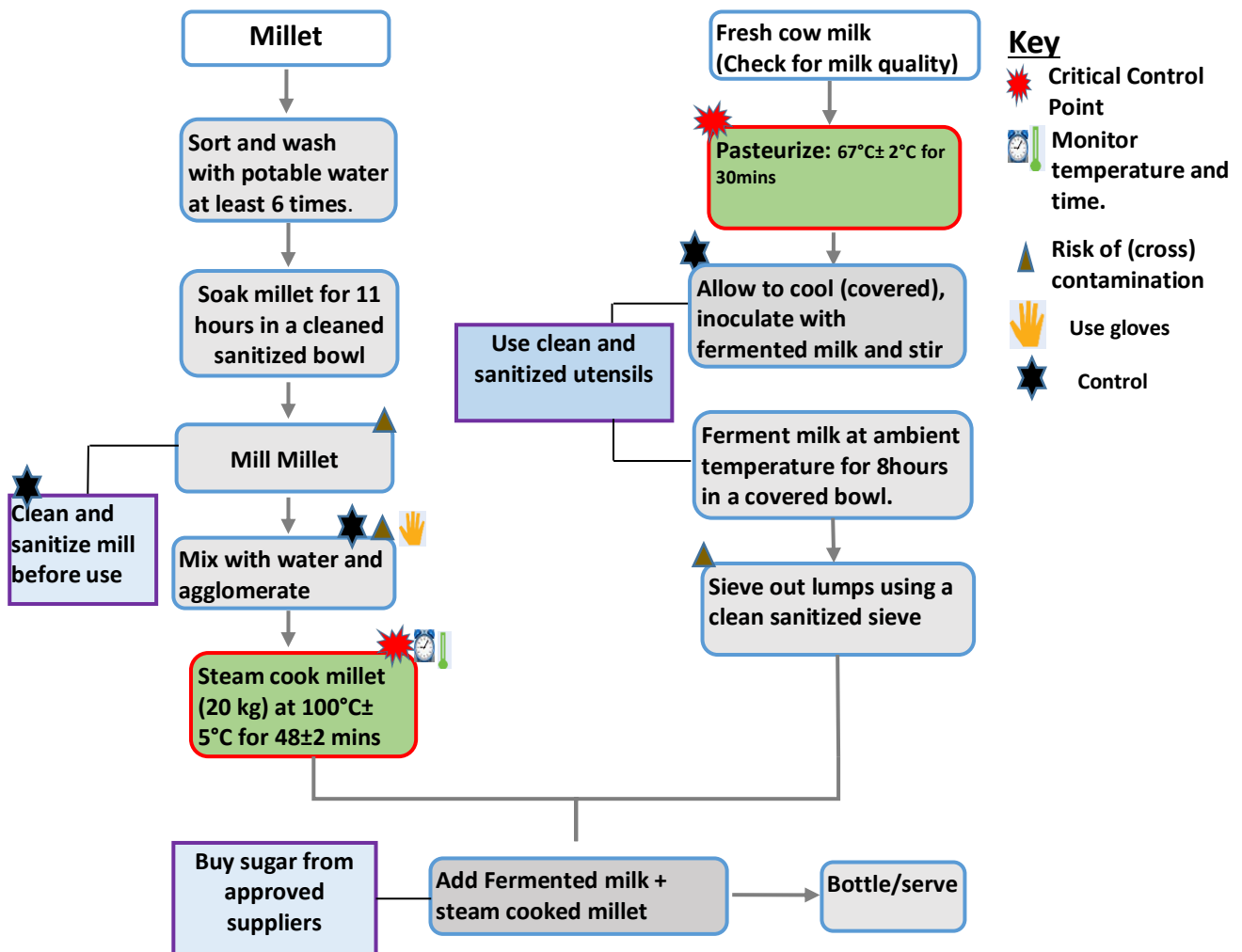


Figure 2: Flow diagram of Hygienic Standard Operation Procedure for optimized brukina production

For instance, there were significant reductions in microbial populations throughout the operation steps as compared to commercial counterparts. Milling in the controlled environment caused further reduction in microbial counts as compared to commercial milled process. This particular operation may be difficult to achieve by *brukina* producers as none of the producers interviewed owned mills. It is, therefore, proposed that drained millet is sent early in the morning to the commercial milling facilities such that the millet is first or one of the first products to be milled to prevent transmission of a heavy microbiological load to millet. Since the commercial mills are cleaned once a day, usually at the end of the day's service or at the beginning of the day's operations, opportunities for cross-contamination are significantly reduced for early morning operations.

In the optimized process, steam cooking reduced total coliforms, *S. aureus*, and total bacteria to undetectable levels, unlike the commercial process. This is a result of ensuring even distribution of heat during steam cooking and preventing exposure of the steam cooked millet during cooling.

Sanitary handling by using the developed SOP ensured microbiologically safe products as total coliforms and *S. aureus* could not be detected in both batch processes compared to the commercial *brukina*. Since total coliforms and *S. aureus* are hygiene indicators, the absence of these microbes in *brukina* obtained from the optimized process suggests that the SOP ensured hygienic and sanitary processing and was efficient in reducing total microbial counts. For this reason, the developed SOP is recommended for adoption by traditional *brukina* producers for optimal hygienic production of *brukina*. It is, however, important to test the SOP in traditional commercial settings for verification prior to rolling out this intervention. The efficient adoption of the developed SOP will depend on appropriate training of the producers on basic principles in food hygiene and safety, quality control and use of the SOP.

CONCLUSION

The study showed poor quality of commercially produced *brukina* with high levels of total coliforms, *S. aureus* and yeasts, and moulds along the production chain.

The study developed an integrated SOP for improved traditional *brukina* through optimization of hygienic handling, processing, and the introduction of quality control and CCP monitoring steps. The concentrations of total bacteria, coliforms, and *S. aureus* reduced to acceptable limits in the final *brukina* produced according to the developed SOP, suggesting that compliance to the SOP will significantly improve microbiological quality and safety of traditional *brukina*.

Table 1: Mean pH and bacteriological quality at different stages of commercial *brukina* production

| <i>Brukina</i> production steps | Mean \pm SD (Log CFU/ml) | | | | |
|--|-------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|
| | Total plate count | Total coliforms | Yeasts and moulds | <i>Staphylococcus aureus</i> | pH |
| Soaked millet | 6.27 \pm 1.04 ^a | 2.77 \pm 2.54 ^b | 4.75 \pm 1.40 ^a | 1.10 \pm 2.31 ^{ad} | 6.48 \pm 0.09 ^{ag} |
| Milled millet | 8.15 \pm 1.09 ^{ab} | 5.15 \pm 1.20 ^{ab} | 6.44 \pm 2.60 ^a | 5.47 \pm 3.06 ^b | 6.57 \pm 0.00 ^{cg} |
| Agglomerated millet | 8.14 \pm 1.19 ^{ab} | 6.08 \pm 1.76 ^b | 6.06 \pm 2.35 ^a | 5.37 \pm 2.88 ^{ac} | 5.90 \pm 0.01 ^b |
| Steam cooked millet | 5.09 \pm 2.71 ^{ac} | 0.93 \pm 2.01 ^{ac} | 4.59 \pm 2.48 ^a | 3.06 \pm 2.73 ^a | 6.28 \pm 0.02 ^c |
| Fermented milk | 7.74 \pm 1.18 ^a | 0.94 \pm 1.98 ^{ac} | 4.51 \pm 3.93 ^a | 3.44 \pm 3.11 ^a | 4.31 \pm 0.01 ^{dh} |
| Final <i>brukina</i> product | 7.48 \pm 1.83 ^a | 2.91 \pm 3.75 ^d | 5.25 \pm 3.19 ^b | 4.68 \pm 2.68 ^a | 4.35 \pm 0.00 ^{fh} |
| ¹ Microbiological limit (cultured milk) | – | – | 3.00 | – | – |

Values with a single or double superscripts that are different within the same column are statistically different at $\alpha=0.05$. The pH values with a single or double superscripts that are different within the same column are statistically different at $\alpha=0.05$ ¹Ghana Standard, GS 955:2013

Table 2: Quality of boiled milk obtained from the production locations using methylene blue reductase test

| Location | Time for colour reaction (hours) | Quality of milk |
|---------------|-------------------------------------|-------------------|
| Ashaiman | 4.50 | Fair quality milk |
| Mataheko | 6.50 | Good quality milk |
| Accra-Newtown | 7.00 | Good quality milk |
| Dansoman | 6.50 | Good quality milk |
| Laboratory | 7.00 | Good quality milk |

Table 3: Comparison of mean microbial counts along the *brukina* production chain from the optimized process and commercial process

| <i>Brukina</i> production steps. | Commercial/ optimized | Mean \pm SD (Log CFU/ml) | | |
|-------------------------------------|--------------------------|-------------------------------|------------------------------|--|
| | | Total plate count | Total coliforms | <i>Staphylococcus</i> <i>aureus</i> |
| Soaked Millet | traditional | 6.31 \pm 1.7 ^a | 2.67 \pm 2.86 ^a | 1.37 \pm 2.54 ^a |
| | optimized | 6.07 \pm 0.03 ^a | 3.17 \pm 0.08 ^a | 0.00 \pm 0.00 ^a |
| Milled millet | traditional | 8.66 \pm 0.19 ^a | 5.69 \pm 4.79 ^a | 3.84 \pm 1.17 ^a |
| | optimized | 6.11 \pm 0.04 ^b | 3.02 \pm 0.29 ^b | 0.00 \pm 0.00 ^b |
| Agglomerated millet | traditional | 8.69 \pm 0.322 ^a | 6.87 \pm 0.70 ^a | 3.72 \pm 0.57 ^a |
| | optimized | 5.94 \pm 0.24 ^b | 2.95 \pm 2.21 ^b | 0.00 \pm 0.00 ^b |
| Steam cooked millet | traditional | 6.38 \pm 0.40 ^a | 1.19 \pm 2.21 ^a | 3.82 \pm 2.49 ^a |
| | optimized | 0.00 \pm 0.00 ^b | 0.00 \pm 0.00 ^b | 0.00 \pm 0.00 ^b |
| Fermented milk | traditional | 8.29 \pm 0.23 ^a | 1.17 \pm 2.17 ^a | 2.30 \pm 2.87 ^a |
| | optimized | 5.53 \pm 0.01 ^b | 0.00 \pm 0.00 ^b | 0.00 \pm 0.00 ^b |
| Final Product | traditional | 8.34 \pm 0.20 ^a | 3.63 \pm 3.89 ^a | 2.83 \pm 1.19 ^a |
| | optimized | 4.06 \pm 0.76 ^b | 0.00 \pm 0.00 ^b | 0.00 \pm 0.00 ^b |

For every product, values in the same column with different superscripts are statistically different at $\alpha=0.05$

Table 4: Monitoring Plan for Critical Control Points (CCP) in SOP

| BIOLOGICAL AGENTS | CCP | MONITORING | CRITICAL LIMIT | VERIFICATION | MEASUREMENT CRITERIA | CORRECTIVE ACTION |
|--|-------------------------|--|----------------------------|---|--|--|
| Vegetative cells of spoilage and pathogenic bacteria | Milk pasteurization | Monitor temperature with a stainless steel temperature probe and time with a stop watch. Timing of pasteurization (30 minutes) should begin when temperature reaches 68±2°C. | 68±2°C for 30 minutes. | Use methylene blue test or resazurin test to verify efficiency of pasteurization. | Colour of milk after addition of resazurin solution should be blue, light blue or purple. Refer to milk testing and payment systems for details on resazurin test [19]. | When milk does not satisfy verification requirement, mix with bulk raw milk and pasteurize or place milk back on heat source immediately and monitor time and temperature till it reaches specified limits |
| Vegetative cells of spoilage and pathogenic bacteria | Steam cooking of millet | Monitor temperature with a stainless steel temperature probe and time with a stop watch. Timing of steam cooking (48±2 minutes) should begin when temperature is 100°C. | 100 ± 5°C for 48±2 minutes | Steam cooked millet should have a temperature of ≥90°C | The topmost part of the millet inside the colander should have a temperature above 90 °C. Insert a clean and sanitized thermometer probe into the millet and record temperature. | When millet does not satisfy verification requirement, reheat millet immediately and monitor temperature and time |



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APPENDIX 1

HYGIENIC STANDARD OPERATING PROCEDURE (SOP) FOR PRODUCTION OF *BRUKINA*

I. PURPOSE:

The purpose of this Standard Operating Procedures is to provide low technology intervention for hygienic processing of *brukina*. This is to prevent entry, kill and or prevent proliferation of microbiological agents that typically contaminates *brukina* during traditional processing operations.

II. SCOPE:

The scope of the SOP covers *brukina* production from receipt of raw materials to packaging and storage of finished product.

III. INTRODUCTION:

Brukina is an indigenous beverage produced by adding steam cooked millet and sugar to fermented milk. It is thick and creamy with visible greyish-black millet granules of about 2.5mm-3.00mm. *Brukina* has a pH of 4.35 with a short shelf life of about 5 - 7 days when stored under chilling conditions.

IV. RAW MATERIALS

Potable water, good quality fresh milk or reconstituted powdered milk, sugar, millet and salt.

V. EQUIPMENT/UTENSILS:

Metallic pot (preferably stainless steel), cups, long metallic stirring ladle, Sieve, metallic pan with perforations at the bottom. NB: The pan must fit the opening of the metallic pot.

VI. INSTRUCTIONS

A. Pre-production guide

1. Ensure production is done in a clean and dry production area.
2. As a rule of thumb, respect the requirements for Good Hygienic Practices.
3. Ensure good personal hygiene prior to production (E.g. keep finger nails short and unpainted, wear clean clothes and/or overalls, avoid wearing of jewellery, cover hair with hair nets).
4. All equipment, utensils, packaging materials and food contact surfaces used for production must be washed with soap and sanitized. Washing removes dirt while sanitization kills germs on food contact surfaces. Washing and sanitization can be combined in a single step when bactericidal soap is used for washing. An example of bactericidal soap is any kitchen grade liquid soap that has the label "kills 99.9% germs" or "antibacterial" inscribed. Alternatively, food contact surfaces can be washed with soap, rinsed with potable water and sanitized with hot water (>85°C). Other approved chemical sanitizers can be used for sanitization according to manufacturer's instructions.
5. All washed and dried utensils awaiting to be used should be temporarily stored/kept in a clean enclosed container.
6. Hands must be washed with bactericidal soap and rinsed thoroughly before start of production and handling of food materials and contact surfaces. Always wash

- hands whenever hands are soiled, when producer(s) touch non-food contacts surfaces, after sneezing or coughing i.e. when hands are used to cover the mouth, after visiting the toilet, and when one resumes from a break during the production.
7. Nose masks must be worn during production or there should be no talking over opened food materials or products during production.

B. Operational guide for milk processing

1. Receive milk from approved or trusted suppliers.
2. Check quality of milk prior to processing (suggested methods for Clot on boiling (C.O.B) test, lactometer test and alcohol test are detailed in Milk testing and payment systems [20].
3. Pasteurize raw cow milk by heating the milk in a covered cleaned and sanitized pot or saucepan. Homogenise the milk during heating with a clean and sanitized stainless steel ladle. Monitor increase in temperature by dipping a clean and sanitized food grade thermometer with a stainless steel probe into the milk. As soon as the thermometer reads $68 \pm 2^{\circ}\text{C}$, start timing for 30 minutes to ensure adequate contact time. **(Critical Control Point)**.
4. Cover the saucepan with a clean and sanitized lid, insert a cleaned and sanitized thermometer and monitor temperature till reduces to $43^{\circ}\text{C} \pm 2^{\circ}\text{C}$. Or cover saucepan and allow milk to cool for 3 hours.
5. Fetch inoculum with a cleaned and sanitized spoon/ladle and add to the cooled pasteurized milk, stir gently with a cleaned and sanitized metallic stirrer and cover the inoculated milk with a clean lid.
6. Allow fermentation for 8 hours at ambient temperature in a clean hygienic environment.

C. Operational guide for millet processing

1. Remove all stones from millet and wash millet at least six times, using potable water or boiled and cooled water for each wash.
2. Soak millet with potable water for 11 hours in a cleaned and sanitized container or bowl covered with a clean lid.
3. Collect millet from water into a clean sieve, cover and allow water to drain.
4. Mill millet using a cleaned and sanitized disc attrition mill and collect milled millet into a different cleaned and sanitized bowl.
5. Add potable water or boiled water to millet, mix with the addition of little salt and roll into granules using gloved hands.
6. Put granulated millet into a clean perforated metallic bowl.
7. Cover the bowl with a tight-fitting metallic lid and steam cook the millet for 45 minutes. **(Critical Control Point)**.
8. Transfer steam cooked millet into a clean bowl, cover with a clean perforated lid and allow it cool for 30 minutes.

D. Operational guide for final mixing

1. Transfer fermented milk into a clean bowl and add steam cooked millet, mixed gently with a cleaned and sanitized stirrer.
2. Add sugar to the mixture and stir using cleaned and sanitized ladle.
3. Fetch *brukina* with a clean and sanitized container, fill into washed bottles and store cold at $\leq 5^{\circ}\text{C}$. (This step is to be done with a gloved hand).