Technical report on the comparison of the effect of two types of ‘fufu’ processing methods on its microbial quality

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Abstract

Traditionally, fufu preparation is time consuming and very labour intensive. Due to changing societal trends, urbanization and the need to make life easy and comfortable, the fufu milling machine was fabricated to enable fufu processors prepare fufu in shorter time frames and with reduced labour. Previous studies on the microbial quality of fufu have shown that the traditionally prepared fufu have high contamination levels with diverse organisms.

The aim of this study was therefore to assess the microbial quality of traditionally processed fufu and mechanically processed fufu sold by 5 vendors in 4 markets (Kaneshie, Lapaz, Madina and Accra Central Markets) in the Greater Accra metropolis. *Salmonella spp*. were not detected in any of the samples. However, yeasts and moulds, *Bacillus cereus*, *Escherichia coli*, *Staphylococcus aureus*, Faecal coliforms, *Enterobacteriaceae* and Coliforms were identified. Total viable counts ranged from 10^3 to 10^7 cfu/g for traditionally processed fufu. Generally, bacterial counts from the milled/extruded fufu were lower than those obtained by the traditional pounding method. The authors therefore recommend the use of the mechanical means of processing fufu which yields fufu that is not as contaminated as the traditional processed fufu, making it safer for human consumption with low levels of risk.

Key words: fufu; food safety, processing, microbial quality

1.0 Introduction

Fufu, a staple food in Ghana is enjoyed by people from various ethnic groups especially the Akans. It is usually consumed with soup and this could either be light soup, groundnut soup, palm nut soup or green vegetable (spinach) soup. In Ghana, fufu is prepared from unripe mature plantain and cassava; from cocoyam, yam or from plantain only.

Generally, the processing of fufu in Ghana is via 2 main methods. The traditional method of processing fufu involves boiling the unripe mature plantain, cassava, yam or cocoyam until cooked. The cooked roots or tubers are then pounded in a mortar with a pestle, turning it frequently with hands moistened with water, until it becomes like dough. It is then molded into balls and served with soup. This process is laborious and time consuming especially if it has to be prepared in large quantities or on a commercial scale. Additionally, due to urbanization and changing lifestyles, many Ghanaian consumers have found the traditional processing method cumbersome. This led to the development of the mechanized processing of fufu, a process that is not as labour intensive as the traditional method (Pouza *et al*., 2016). The fufu milling machine is available in several localities as such, fufu can be classed as a street food. With the mechanized process, the cooked roots or tubers are put in the fufu milling machine. The mill then mechanically processes the fufu and is extruded as a dough. At this point, the dough is sent to the chop bar, restaurant or the home where it is pounded for a short duration and molded into balls for consumption (Amissah & Owusu, 2012).

2.0 Literature Review

Some studies have been done in Ghana on the microbial quality of various street foods (Mensah *et al.*, 2012). A study conducted by Mensah *et al* (2002) on the safety of street foods in Accra showed that various street foods including fufu were contaminated. According to Mensah *et al*., (2002) sources of contamination could be from the equipment, from the hands of people preparing the fufu or from the water should in moisten the hands during the processing of fufu. In the study conducted by Mensah *et al*., (2002) ten samples of fufu was taken from various parts of Accra and analyzed. The bacteria identified in the fufu samples were *Bacillus* spp, *Enterobacteriaceae*, and *Staphylococcus aureus*. The bacterial counts were 0.4+1.19 log 10 cfu/g, 4.2+1.56 log 10 cfu/g and 2.9+1.69 log 10 cfu/g for *Bacillus* spp, *Enterobacteriaceae* and *Staphylococcus aureus* respectively. The total bacterial plate count was 6.2+1.57 log 10 cfu/g. *Enterobacteriaceae* isolated from the fufu samples were *C. diversus, E. cloacae* and *E. sakazakii (*Mensah *et al.,* 2012*).* Another study was conducted by Amissah & Owusu (2012) assessing the microbial quality of food sold on and around Koforidua Polytechnic campus.

Their results indicated that, two samples of fufu tested positive for *Staphylococccus aureus* and *E. coli*, with mean bacterial counts of $>7.0 \times 10^3 \pm 1.0 \times 10^1$ cfu/g and $> 1.0 \times 10^3 \pm 1.1 \times 10^1$ cfu/g respectively.

Although the fufu samples analyzed by Amissah & Owusu (2012) did not contain *Salmonella*, counts for *Escherichia coli* from two sampling locations were $>1.0 \times 10^3 \pm 1.1 \times 10^1$cfu/g. For *Staphylococcus aureus*, fufu from two locations on Koforidua Polytechnic campus were 7.0×10^3 and 5.0×10^3 cfu/g respectively.

Feglo & Sakyi (2012) also investigated bacterial contamination in street vended food in Kumasi. The fufu samples analyzed as part of the study had a mean bacterial count of 6.36 log10 cfu/g. The levels of contamination in fufu were 3.7% coagulase negative *Staphylococci*, 3% *Bacillus* sp., 0.7% *Aeromonas* sp., 0.7% *Enterobacter* sp. and 0.7% *Pseudomonas aeruginosa*.

As part of a study conducted by Boateng (2015), the microbial quality of selected foods sold on the streets by vendors in Upper Denkyira East Municipality of the Central region of Ghana were assessed. Out of 6 samples of fufu analysed, faecal coliforms were isolated from 2 of the samples. *Staphylococcus aureus* were isolated in 2 fufu samples and *Salmonella typhi* was not detected in the fufu samples.

The microbial quality of ready-to-eat foods sold in the Sunyani Municipality were also assessed (Ofosu *et al*., 2014). Their results show that total microbes were too numerous to count. *Enterobacteriaceae* counts were 4.2±1.56 log 10 cfu/g. Coliform counts were 22 cfu/g. The specific *Enterobacteriaceae* isolated from the fufu samples were *C. diversus*, *E. cloacae* and *E. sakazakii*. Fungi isolated were *Aspegillus niger*, *Penicillium citrium*, yeast, *Clasdosporium herbadum*, *Aspegillus* sp and *Fusarium* sp. (Ofosu *et al*., 2014).
In light of this information that shows that traditionally prepared fufu had high bacterial counts of diverse organisms, this study therefore sought to determine the effect of processing on the microbial quality of fufu prepared via the traditional processing method with the mechanical processed fufu.

3.0 Methodology

3.1 Sampling

Ready-to-eat fufu was sampled from four markets namely Kaneshie, Lapaz, Madina and the Accra Central Markets of the Greater Accra Metropolis. At the markets, fufu was purchased randomly from 5 vendors within a period of three months. The fufu samples were stored in a cooled ice chest and transported to the laboratory for microbial analysis. The samples were analyzed to enumerate total viable counts, coliforms, *Escherichia coli, Enterobacteriaceae, Staphylococcus aureus,* Yeast and molds, Faecal coliforms and *Bacillus cereus* and detection of *Salmonella*.

3.2 Microbiological Analyses

3.2.1 Homogenization and Serial Dilution

For all solid samples, ten grams (10 g) were added to 90.0 ml sterile Salt Peptone Solution (SPS) containing 0.1 % peptone and 0.8 % NaCl, with pH adjusted to 7.2 and homogenized in a stomacher (Lad Blender, Model 4001, Seward Medical, England), for 30 s at normal speed. From appropriate ten-fold dilutions 1 ml aliquots of each dilution was directly inoculated into sterile Petri dish plates and the appropriate media added for enumeration of microorganisms. All analyses were done in duplicate.

3.2.2 Enumeration of Aerobic Mesophiles

Aerobic mesophiles were enumerated by the pour plate method on Plate Count Agar medium (Oxoid CM325; Oxoid Ltd., Basingstoke, Hampshire, UK). Plates were incubated at 30°C for 72h in accordance with NMKL. No. 86, 2006.

3.2.3 Enumeration of Yeast and moulds

Yeasts and moulds were enumerated by the spread plate method on Dichloran Rose Bengal Chloramphenicol Agar (Oxoid CM0727), pH 5.6, containing Chloramphenicol supplement to prevent bacteria growth and incubated at 25 °C for 3-5 days in accordance with (ISO 21527-1:2008 to which chloramphenicol supplement was added to suppress bacteria growth. The pH was adjusted to 5.6 and incubated at 25 °C.

3.2.4 Enumeration of Coliforms, Faecal coliform and *E. coli*

Total coliforms and *E. coli* were enumerated by pour plate on Trypton Soy Agar (Oxoid CM131), pH 7.3 overlaid with Violet Red Bile Agar (Oxoid CM107), pH 7.4 and incubated at 37 °C for 24 h for total coliforms and at 44 °C for 24 h for *E. coli*. Colonies suspected to be coliforms were confirmed on Brilliant Green Bile Broth (Oxoid CM31), pH 7.4, incubated at 37 °C for 24 h according to NMKL No. 44 (2004). Suspected Faecal coliforms and *E. coli* colonies were confirmed in EC Broth for gas formation (Oxoid CM853), pH 6.9. Positive tubes were again sub cultured into Trypton Water (Oxoid CM87), pH 7.5, all incubated at 44 °C for 24 h after which Indole test was performed for *E. coli* according to NMKL No. 125 (2005).

3.2.5 Enumeration of *Staphylococcus aureus*

Staphylococcus aureus was determined by spread plate on Baird Parker Agar (BP, CM 275 Oxoid Ltd, Hampshire, England) with Egg Yolk Tellurite Emulsion (SR54) added and Blood Agar Base (BAB, CM 55 Oxoid Ltd, Hampshire, England). Both media were incubated at 37 °C for 48 h. *S. aureus* counts were confirmed by biochemical tests according to NMKL Method No. 66 (2009).

3.2.6 Enumeration of *Bacillus cereus*

Bacillus cereus was determined by spread plate on Bacillus cereus Agar (BP, CM 275 Oxoid Ltd, Hampshire, England) with Egg Yolk Emulsion (SR54), *Bacillus cereus* supplement and Blood Agar Base (BAB, CM 55 Oxoid Ltd, Hampshire, England). Both media were incubated at 30 °C for 24 h. *B. cereus* counts were confirmed by microscopy according to NMKL Method No. 67 (2010).

4.0 Results and Discussion

Table 1 and 2 show the total viable counts (TVC) and Coliform counts respectively. The traditionally processed fufu had higher bacterial counts than the machine processed fufu. For TVC, values as high was 10^7 cfu/g was reported at Accra Central whilst 10^4 cfu/g was reported for the Machine extruded / processed fufu. With the coliform counts, values of 10^4 cfu/g were recorded for the traditionally processed fufu and in Kaneshie and Lapaz markets, there were no coliforms (<10cfu/g). Total viable counts or Aerobic Plate Count of ready-to-eat foods should be at a level of $<10^3$ to be categorized as satisfactory. Counts between 10^3– 10^5 are borderline and counts $\geq 10^5$ are classed as unsatisfactory. Although high levels of bacterial count are not indicators of safety, high bacterial counts indicate a poor quality product (Health Protection Agency (HPA), 2009). From table 1, it is therefore evident that bacterial counts for traditionally prepared fufu are unsatisfactory whilst the machine processed fufu counts falls in the borderline range.

Table 1

TVC of traditional and extruded (milled) processed fufu from five vendors at different markets locations in Greater Accra district

Vendor	Traditional processed fufu				Machine (extruded) processed fufu			
	Kaneshie	**Lapaz**	**Madina**	**Accra central**	**Kaneshie**	**Lapaz**	**Madina**	**Accra central**
1	$(2.2\pm1.2)10^6$	$(8.3\pm1.1)10^5$	$(4.7\pm1.9)10^6$	$(1.3\pm1.6)10^7$	$(4.3\pm0.7)10^4$	$(6.0\pm1.8)10^4$	$(1.3\pm1.2)10^4$	$(1.6\pm0.7)10^4$
2	$(8.2\pm1.3)10^6$	$(7.5\pm0.8)10^5$	$(1.5\pm2.0)10^6$	$(9.2\pm2.8)10^5$	$(8.9\pm1.2)10^3$	$(1.2\pm2.1)10^4$	$(3.8\pm0.4)10^4$	$(4.5\pm0.5)10^3$
3	$(7.6\pm0.9)10^5$	$(1.7\pm1.8)10^6$	$(9.7\pm02.3)10^5$	$(8.4\pm3.2)10^6$	$(2.9\pm1.8)10^4$	$(5.4\pm1.5)10^4$	$(2.1\pm0.9)10^3$	$(9.5\pm1.6)10^3$
4	$(9.7\pm1.2)10^5$	$(6.4\pm2.4)10^5$	$(8.6\pm1.1)10^6$	$(1.9\pm1.5)10^6$	$(4.0\pm1.1)10^4$	$(3.8\pm0..7)10^4$	$(7.1\pm1.0)10^4$	$(3.4\pm1.1)10^3$
5	$(6.8\pm2.6)10^5$	$(2.3\pm1.6)10^6$	$(1.6\pm2.2)10^5$	$(5.3\pm2.0)10^6$	$(3.4\pm0.8)10^3$	$(6.4\pm0.9)10^3$	$(1.3\pm1.4)10^4$	$(8.8\pm0.9)10^4$

Table 2

Coliform counts of traditional and extruded processed fufu from five different markets at different locations in Greater Accra district

Vendor	Traditional processed fufu				Machine processed fufu			
	Kaneshie	**Lapaz**	**Madina**	**Accra central**	**Kaneshie**	**Lapaz**	**Madina**	**Accra central**
1	$(1.3\pm1.4)10^3$	$(4.4\pm1.7)10^4$	$(1.4\pm1.1)10^3$	$(6.0\pm0.7)10^3$	$(4.1\pm0.5)10^2$	$(5.8\pm0.9)10^2$	$(2.1\pm0.8)10^2$	$(4.6\pm0.4)10^2$
2	$(7.6\pm2.2)10^2$	$(3.8\pm0.4)10^2$	$(1.8\pm0.9)10^4$	$(1.3\pm1.9)10^4$	$(5.8\pm0.2)10^1$	$(1.9\pm0.3)10^1$	$(9.7\pm0.3)10^1$	$(9.8\pm0.2)10^2$
3	$(8.2\pm1.9)10^3$	$(1.0\pm1.3)10^3$	$(1.0\pm1.5)10^3$	$(8.4\pm0.2)10^3$	0	$(6.4\pm0.7)10^2$	$(2.0\pm0.4)10^2$	$(5.0\pm0.7)10^2$
4	$(1.7\pm0.4)10^4$	$(6.1\pm0.7)10^4$	$(3.1\pm0.3)10^4$	$(1.2\pm1.4)10^3$	$(5.2\pm0.6)10^2$	$(3.7\pm0.6)10^2$	$(5.2\pm0.3)10^1$	$(4.4\pm0.9)10^2$
5	$(9.5\pm0.5)10^3$	$(1.1\pm1.4)10^4$	$(5.6\pm1.6)10^3$	$(1.3\pm2.1)10^4$	0	0	$(4.1\pm0.7)10^2$	$(2.0\pm0.6)10^1$

Coliform are used as an indicator of hygiene and their presence in food or water indicates that preparation was not done under hygienic conditions. With the fufu samples, the presence of coliforms could be indicative of post processing contamination as a result of the contaminated hands (Ontario Public Health).

Table 3

Faecal coliform counts of traditional and extruded processed fufu from five different markets at different locations in Greater Accra district.

Traditional processed fufu				**Machine processed fufu**			
Kaneshie	**Lapaz**	**Madina**	**Accra central**	**Kaneshie**	**Lapaz**	**Madina**	**Accra central**
$(8.3\pm0.4)10^3$	$(1.8\pm0.9)10^2$	$(7.5\pm0.3)10^2$	$(1.2\pm0.5)10^2$	0	$(3.6\pm0.8)10^2$	$(2.3\pm0.7)10^1$	$(6.4\pm0.6)10^2$
$(6.3\pm0.8)10^2$	$(7.3\pm0.2)10^3$	$(8.7\pm0.7)10^3$	$(3.6\pm1.0)10^2$	$(1.6\pm0.7)10^1$	0	0	$(3.7\pm0.3)10^2$
$(1.4\pm0.6)10^2$	$(1.8\pm0.5)10^2$	$(6.3\pm0.6)10^2$	$(1.7\pm0.9)10^3$	0	$(1.1\pm0.5)10^2$	$(4.6\pm0.9)10^1$	$(3.2\pm1.4)10^3$
$(9.4\pm0.3)10^2$	$(6.7\pm0.7)10^3$	$(1.1\pm0.9)10^2$	$(8.1\pm1.4)10^2$	$(1.3\pm0.2)10^1$	$(4.1\pm0.7)10^1$	0	$(2.4\pm1.9)10^3$
$(1.2\pm1.3)10^3$	$(1.2\pm1.9)10^3$	$(3.3\pm0.4)10^2$	$(8.2\pm1.1)10^3$	0	0	$(7.2\pm0.3)10^2$	$(3.1\pm1.2)10^3$

With table 3, the table the shows the counts of faecal coliforms. The traditional processed fufu generally had higher counts of faecal coliforms as compared with the machine processed fufu. The levels of faecal coliforms found in the traditional and machine processed fufu were unacceptable as per criteria for ready-to-eat foods (HPA, 2009).

Table 4

E. coli of traditional and extruded processed fufu from five different markets at different locations in Greater Accra district

Traditional processed fufu				**Machine processed fufu**			
Kaneshie	**Lapaz**	**Madina**	**Accra central**	**Kaneshie**	**Lapaz**	**Madina**	**Accra central**
0	$(1.7\pm0.2)10^1$	0	$(1.1\pm0.4)10^1$	0	0	0	0
0	0	$(4.2\pm0.3)10^1$	0	0	0	0	0
$(3.8\pm0.5)10^1$	0	0	0	0	0	0	$(3.3\pm0.9)10^1$
0	$(5.6\pm0.3)10^1$	$(1.1\pm0.9)10^1$	0	0	0	0	0
$(4.1\pm0.9)10^2$	$(3.6\pm0.8)10^2$	0	$(4.1\pm1.1)10^2$	0	0	0	0

Results in table 4 depicts the levels of *Escherichia coli* enumerated from the traditional and machine processed fufu. Counts of 10^2 cfu/g were obtained from 3 out of 20 vendors and only one vendor at Accra Central had a count of 10^1 cfu/g. The trend also indicated that counts were higher with the traditional processing method. Reference guidelines from HPA (2009) indicate that *E. coli* counts > 10^2 are unsatisfactory, 20 - $\leq 10^2$ are borderline and <20 are satisfactory.

Table 5

S. aureus of traditional and extruded processed fufu from five different markets at different locations in Greater Accra district

Traditional processed fufu				**Machine processed fufu**			
Kaneshie	**Lapaz**	**Madina**	**Accra central**	**Kaneshie**	**Lapaz**	**Madina**	**Accra central**
$(2.0\pm1.4)10^3$	$(9.0\pm0.8)10^2$	$(4.2\pm0.3)10^4$	$(1.8\pm0.6)10^2$	$(9.0\pm0.2)10^1$	$(8.5\pm0.4)10^1$	$(5.5\pm0.2)10^2$	$(4.6\pm1.7)10^2$
$(8.5\pm1.2)10^2$	$(2.3\pm0.5)10^2$	$(6.8\pm1.4)10^3$	$(1.8\pm0.3)10^2$	0	$(3.0\pm0.7)10^1$	0	$(2.6\pm0.5)10^1$
$(1.5\pm0.9)10^2$	$(8.0\pm1.3)10^3$	$(8.8\pm1.1)10^3$	$(3.1\pm0.9)10^3$	$(8.9\pm0.9)10^2$	$(9.0\pm0.5)10^1$	$(2.6\pm0.8)10^3$	$(2.8\pm0.8)10^2$
$(2.2\pm1.6)10^2$	$(8.5\pm0.1)10^1$	$(3.8\pm0.7)10^2$	$(8.8\pm1.5)10^3$	$(2.9\pm0.5)10^2$	$(2.0\pm0.9)10^2$	$(2.4\pm0.6)10^1$	$(4.4\pm0.3)10^1$
$(4.1\pm1.8)10^3$	$(2.2\pm0.7)10^2$	$(3.1\pm1.7)10^3$	$(3.5\pm0.7)10^2$	0	$(3.7\pm0.4)10^2$	$(4.2\pm1.3)10^2$	0

Traditionally processed fufu recorded bacterial counts ranging from 10^1 to 10^4 cfu/g and machine processed fufu ranged from 0 to 10^2 cfu/g. *Staphylococcus aureus* although found commonly on the skin and hair as well as in the noses and throats of people and animals can find its way into food and cause food poisoning when a food handler contaminates food or from equipment and surfaces the food comes in contact with. Additionally, because fufu is usually kept at ambient temperature it results in rapid multiplication of these bacteria and could lead to toxin production at counts of $>10^5$cfu/g which results in foodborne illness (Forsythe, 2000; www.foodsafety.gov). For *Staphylococcus*, counts above $>10^4$ are unsatisfactory because these levels are potentially unfit for human consumption. Counts between 20-$\leq 10^4$ are classed as borderline and <20 is satisfactory. From table 5, *Staphylococcus aureus* counts were borderline for traditional processing methods and mechanically processed. Mechanically processed fufu however was of a better microbial quality than the traditionally prepared fufu.

Table 6

Yeast and moulds of traditional and extruded processed fufu from five different markets at different locations in Greater Accra district

Traditional processed fufu				**Machine processed fufu**			
Kaneshie	**Lapaz**	**Madina**	**Accra central**	**Kaneshie**	**Lapaz**	**Madina**	**Accra central**
$(6.1\pm1.8)10^4$	$(4.1\pm1.9)10^4$	$(1.7\pm1.4)10^3$	$(5.5\pm2.6)10^4$	$(9.9\pm0.5)10^2$	$(2.0\pm0.7)10^2$	$(7.1\pm0.3)10^2$	$(5.6\pm1.7)10^3$
$(2.9\pm0.7)10^5$	$(5.4\pm2.1)10^4$	$(2.5\pm0.9)10^4$	$(6.1\pm1.4)10^3$	$(3.4\pm0.3)10^2$	$(7.5\pm1.2)10^3$	$(4.8\pm0.7)10^2$	$(1.9\pm2.4)10^3$
$(5.2\pm1.3)10^4$	$(3.9\pm0.9)10^4$	$(4.8\pm0.5)10^5$	$(4.7\pm1.8)10^3$	$(4.5\pm0.2)10^3$	$(4.6\pm0.8)10^2$	$(3.9\pm1.1)10^3$	$(3.9\pm1.4)10^3$
$(5.4\pm2.1)10^4$	$(1.8\pm1.7)10^3$	$(4.5\pm1.1)10^3$	$(9.1\pm1.9)10^3$	$(3.4\pm0.9)10^3$	$(6.3\pm1.9)10^3$	$(3.8\pm0.4)10^2$	$(1.7\pm1.8)10^3$
$(2.1\pm1.2)10^4$	$(3.9\pm1.2)10^3$	$(2.7\pm1.4)10^4$	$(6.1\pm0.9)10^4$	$(3.7\pm0.3)10^1$	$(7.6\pm0.4)10^4$	$(8.7\pm0.3)10^2$	$(2.7\pm0.7)10^2$

Yeast and moulds although they do not cause foodborne illness, their presence in food leads to rapid spoilage. Counts ranged from 10^3 to 10^5cfu/g for traditionally processed fufu and 10^1 to 10^4 cfu/g for machine processed fufu.

Table 7

Bacillus cereus of traditional and extruded processed fufu from five different markets at different locations in Greater Accra district

Vendor	Traditional processed fufu				Machine processed fufu			
	Kaneshie	**Lapaz**	**Madina**	**Accra central**	**Kaneshie**	**Lapaz**	**Madina**	**Accra central**
1	$(3.6\pm2.4)10^4$	$(3.8\pm1.4)10^3$	$(4.3\pm1.6)10^3$	$(6.6\pm0.9)10^3$	$(3.5\pm0.2)10^1$	(1.2 ± 1.1) 10^2	$(6.4\pm0.7)10^2$	$(2.3\pm1.2)10^2$
2	$(4.2\pm1.8)10^3$	$(3.4\pm0.7)10^4$	$(5.6\pm2.1)10^4$	$(5.2\pm0.5)10^4$	(1.0 ± 0.4) 10^2	$(1.2\pm0.6)10^2$	$(2.3\pm0.4)10^1$	$(1.8\pm0.9)10^2$
3	$(1.8\pm2.1)10^4$	$(2.7\pm0.9)10^3$	$(4.8\pm1.9)10^3$	$(4.4\pm0.2)10^3$	$(2.2\pm0.3)10^1$	$(4.0\pm0.9)10^2$	(2.5 ± 0.6) 10^2	$(6.6\pm0.3)10^1$
4	$(7.4\pm0.4)10^3$	$(5.2\pm0.6)10^3$	$(3.3\pm1.8)10^4$	$(5.1\pm0.7)10^4$	(4.3 ± 1.0) 10^2	$(5.0\pm0.3)10^2$	$(8.8\pm0.5)10^1$	$(3.2\pm0.4)10^2$
5	$(9.6\pm1.7)10^4$	$(8.3\pm0.1.1)10^3$	$(8.9\pm1.2)10^3$	$(7.8\pm1.3)10^3$	(5.1 ± 1.3) 10^2	$(3.3\pm0.2)10^1$	$(2.3\pm0.8)10^2$	(2.2 ± 0.7) 10^2

Bacillus cereus is a type of bacteria that produces toxins. These toxins can cause two types of illness: one type characterized by diarrhoea and the other, called emetic toxin, by nausea and vomiting. These bacteria when present in foods and can multiply quickly at room temperature (www.foodsafety.gov). The traditionally prepared fufu recorded *B. cereus* counts within 10^3 to 10^4 cfu/g whilst the machine fufu recorded counts of 10^1 to 10^2 cfu/g. According to Forsythe (2000) food is considered acceptable when it has *B. cereus* counts of less than 10^2cfu/g. The counts reported for mechanically processed fufu were between $10^1 - 10^2$ cfu/g however for the traditionally processed fufu, counts of $10^3 - 10^4$ cfu/g of *B. cereus* were obtained. *B. cereus* is ubiquitous in the environment in low numbers and occur in foods especially rice, however foodborne illness as a result of *B. cereus* contamination has also been associated with starchy foods which may have contributed to the high levels in the traditional and mechanically processed fufu. *B. cereus* counts of $>10^6$cfu/g is potentially hazardous (Forsythe, 2000). According to the Health Protection Agency's guidelines for ready-to-eat foods, *B. cereus*

counts of $>10^5$ cfu/g is categorised as unsatisfactory, 10^3-$\leq 10^5$ cfu/g as borderline and $<10^3$ cfu/g as satisfactory. In comparison with the HPA's guideline, all samples of mechanically processed fufu were satisfactory however the traditionally processed samples were borderline.

Table 8

Enterobacteriaceae of traditional and extruded processed fufu from five different markets at different locations in Greater Accra district

Vendor	**Traditional processed fufu**				**Machine processed fufu**			
	Kaneshie	**Lapaz**	**Madina**	**Accra central**	**Kaneshie**	**Lapaz**	**Madina**	**Accra central**
1	$(3.3\pm1.6)10^4$	$(5.4\pm1.4)10^4$	$(3.5\pm1.3)10^3$	$(5.4\pm1.7)10^3$	$(6.4\pm1.5)10^2$	$(6.5\pm1.5)10^2$	$(4.3\pm1.5)10^2$	$(2.5\pm1.3)10^2$
2	$(9.4\pm1.9)10^4$	$(6.6\pm1.4)10^3$	$(2.4\pm1.9)10^4$	$(7.7\pm0.9)10^4$	$(5.6\pm1.4)10^2$	$(3.7\pm1.2)10^2$	$(7.5\pm1.7)10^3$	$(3.7\pm0.9)10^2$
3	$(3.8\pm1.7)10^3$	$(3.4\pm1.8)10^4$	$(3.9\pm1.7)10^4$	$(4.3\pm1.2)10^4$	$(4.3\pm0.8)10^2$	$(4.8\pm08)10^2$	$(6.6\pm0.7)10^2$	$(7.3\pm1.4)10^2$
4	$(8.4\pm1.1)10^3$	$(6.8\pm0.9)10^4$	$(2.5\pm0.9)10^4$	$(6.8\pm1.6)10^3$	$(7.9\pm1.5)10^2$	$(7.4\pm0.5)10^2$	$(3.4\pm1.2)10^3$	$(6.8\pm1.3)10^2$
5	$(4.8\pm1.3)10^4$	$(3.6\pm1.8)10^3$	$(6.3\pm1.8)10^3$	$(3.8\pm1.9)10^4$	$(4.6\pm1.3)10^3$	$(4.8\pm1.3)10^3$	$(5.8\pm1.5)10^2$	$(3.5\pm1.4)10^3$

Enterobacteriaceae are hygiene indicator organisms. Levels of $>10^4$ cfu/g makes the product unsatisfactory. Bacterial counts between 10^2-$\leq 10^4$ cfu/g is acceptable and counts $<10^2$ cfu/g is satisfactory. Possible sources of contamination of the fufu with *Enterobacteriaceae* could have been through cross contamination from food handlers, contamination from utensils as well as abuse of temperature and time control. Machine processed fufu samples had acceptable levels of *Enterobacteriaceae* whilst some samples of traditional fufu were almost unsatisfactory.

Tables 5, 6, 7, and 8 depict results for *Staphylococcus aureus*, Yeast and moulds, *Bacillus cereus* and *Enterobacteriaceae*. With these bacteria, the trend was the same with counts from traditional fufu processing being higher than for the processed fufu. However, *Salmonella* was not detected in any of the traditional and extruded processed fufu samples taken from the different locations. The traditional fufu preparation / processing method involves a lot of handling of the cooked ingredients and also touching of the dough with the bare hands whilst turning it in the mortar (Mensah *et al*, 2002). Additionally, during the process, water is used to moisten the mortar making it easier to turn the dough and these could account for the incidences of high bacterial counts with the traditional method as compared with the machine fufu. Fufu is eaten without further cooking, processing or heat treatment and as such the presence of high counts of pathogenic bacteria and spoilage bacteria is unacceptable for human consumption. The presence of faecal coliforms with counts ranging from 10^1 to 10^3cfu/g for both traditional and milled fufu is an indication of contamination with faeces and the possibility of the presence of pathogenic bacteria.

5.0 Conclusion

The availability of the fufu milling machine in the Ghanaian communities and markets is timely because results of this study show that fufu prepared the traditional way recorded higher counts of total viable bacteria with the presence of some pathogenic bacteria such as *E. coli*, *Staphylococcus aureus*, *Bacillus cereus* and other food spoilage bacteria, as compared with counts from the machine milled fufu. Therefore the machine processed fufu is of a better microbial quality. Intensive educational campaign and training should be embarked upon to make processors aware of the sources of hazards and procedures or protocols they can adopt during processing of fufu to make the machine milled fufu safe with very low or no bacterial counts. There is the need for further work to be done to investigate the microbial quality of the other types of fufu, such as the fufu prepared from fufu flours, fufu prepared in blenders and in the microwave.

Conflicts of Interest

The authors declare there are no conflicts of interest.

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