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Quality Assessment of *Fufu* Produced with Different Fermentation Aids (Detergent, Kerosene and Palm Ash)

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Abstract
Fufu, a fermented wet-paste from cassava is being prepared by different methods, and different substances are being used to fasten its fermentation. There are concerns that these substances may pose health risks to consumers. Wet *fufu* mashe and dough were produced with different fermentation aids (detergent, kerosene and palm ash) and with a control (without fermentation aid). The *fufu* mash flour, wet mash and dough samples were subjected to chemical and surfactant analysis and sensory evaluations. The results of the amylose contents of the *fufu* mash flour ranged from 12.080% - 21.230%, amylopectin 78.769% - 87.092%, free sugar 2.175% - 5.215% and starch 70.775% - 85.475%. The anionic surfactant levels of the wet *fufu* mash ranged from 0.02mg/l – 0.16mg/l, Cationic surfactant 0.02mg/l – 0.18mg/l, while the anionic surfactant level of the cooked *fufu* dough ranged from 0.01mg/l – 0.13mg/l and Cationic surfactant 0.01mg/l – 0.16mg/l. The total hydrocarbon level of the wet *fufu* mash ranged from 0.15mg/l – 2.77mg/l, while that of the cooked *fufu* dough ranged from 0.12mg/l – 1.86mg/l. The Sensory evaluation result shows that the overall acceptance score ranged from 8.50 - 9.20. There were no significant differences among all the *fufu* samples analysed in the sensory evaluation.

Keywords: Fufu, detergent, kerosene, palm ash, fermentation-aids

Introduction

The starchy roots of cassava (*Manihot esculenta* Crantz), a prominent root crop in the tropics, provide more than 500 million people globally with a large amount of calories (Uyoh *et al*., 2009). In Nigeria, it is the most significant root crop in terms of ensuring food security, generating revenue for households that grow crops, and creating jobs (Ugwu and Ukpabi, 2002). It is mostly used to make flour, *gari, abacha, lafun*, and *fufu*, among other foods. A fermented cassava wet paste is known as *fufu* (Oyewole and Sanni, 1995). It is being processed using a variety of diverse techniques and local customs. Additionally, this differs from region to region within the nation. . In the eastern region of Nigeria, fufu is made by fermenting either peeled or unpeeled cassava (to get soft fermented pulp), wet sifting, and dewatering to get wet fufu mash. To make the *fufu* dough, the mashed mixture is subsequently formed into balls, cooked, and pounded to create the *fufu* dough. The mash could also be dissolved in water in a pot and heated in order to produce the *fufu* dough. Both procedures involve heating the starch to gelatinize it. Traditionally, *fufu* is sold both in wet form (approximately 50% moisture) and as prepared *fufu* dough (Omodamiro *et al*., 2011). The effectiveness of the fermentation process and the dry matter content of the cassava both affect the *fufu* yield. The cassava won't produce high *fufu* mash yield if the fermentation isn't done properly. To maximize profit, some local women who trade in fufu for their daily livelihood and for domestic consumption have turned to some practices to induce quick and efficient fermentation. They add powder detergents (such Ariel and Omo), kerosene, and potash from palm fruit tree (palm ash) to the mixture help the fermentation process. There is a need for research on the amount of these fermentation agents left in the intermediate and processed fufu given the rise in non-communicable disease-related health issues brought on by the influx of chemicals and other health-challenging compounds from processed foods.

Materials and Methods

Experimental design/layout

The experiment was carried out using a single variety of cassava obtained from a single supplier. This was done to eliminate cassava varietal effect on fermentation.

Source of raw materials

The cassava root was obtained and identified by the cassava programme of National Root Crop Research Institute Umudike. The variety of cassava used was TME 419. The selection of the variety was based on how widely farmers and processors accept it as a variety for producing high-quality *fufu* among other products. For cassava breeders, it is used as a national check.

Sample preparation

After peeling, 80 kg of cassava roots (TME419) were washed, and divided into 4 equal (20kg each) lots. In accordance with the local processor's specifications, one of the lots was added kerosene (7mls), another lot was added powdered detergent (7.0g) and the third lot was added ash from palm fruit bunch (10.0g). Without anything added to it, the fourth lot was used as the control. They were soaked for 72-hours. This period was taken from the works of Oyewole and Sanni (1995), who reported that 72 hours is the ideal amount of time for fermentation, as well as a local processor who claims that a typical fermentation day lasts three days. To make the mash, the fermented roots were sieved and dewatered. The dewatered, sieved mash was formed into balls, simmered for about 15 minutes, then taken out and pounded to create the *fufu* dough. To complete the *fufu* dough making, the previously pounded dough was re-molded, cooked for another 10 minutes, and then pounded again (Fig 1).

Determination of amylose content

The amylose content of the *fufu* samples was determined using the method of Williams *et al*, (1970) involving the preparation of stock iodine solution and iodine reagent. A 1.0 g of the sample was weighed into a 100 mL volumetric flask, and then 1 mL of 99.7-100% (*v/v*) ethanol and 9 mL 1N sodium hydroxide was carefully added. The mouth of the flask was covered with parafilm and the contents were properly mixed. The samples were heated for 10 min in a boiling water bath to gelatinize the starch (the timing started when boiling began). The samples were removed from the water bath, allowed to cool, then made up to the mark with distilled water, and shaken thoroughly. Then 5 mL was pipetted into another 100 mL volumetric flask and 1.0 mL of 1N acetic acid and 2.0 mL of iodine solution was added. The flask was topped up to the mark with distilled water. Absorbance (A) was read using a spectrophotometer at 620 nm wavelength. The blank which contained 1 mL of ethanol and 9 mL of sodium hydroxide was boiled and topped up to the mark with distilled water. Finally, 5 mL was pipetted into a 100 mL volumetric flask; 1 mL of 1N acetic acid and 2 mL of iodine solution was added and then topped up to the mark. This was used to standardize the spectrophotometer at 620 nm. The amylose content was calculated as follows:

Amylose content (%) = 3.06 x absorbance x 20

Amylopectin content

Amylopectin content was calculated using the equation explained by Torruco-Uco *et al.* (2006). The average amylose content value was taken for the calculation.

Amylopectin = (100 – Amylose %)

Starch and sugar contents

The calorimetric method of determination of sugars and related substances by Dubois *et al* (1976) was employed. One millimeter (1ml) of 95% ethanol, 2ml of distilled water and 10 ml of hot ethanol was added to 0.02g sample, vortexed and centrifuged for 10 min at 2000rpm. The supernatant was decanted and 9ml of distilled water was added. Quantities of (0.8 ml) distilled water, 0.5 ml phenol and 25ml H_2SO_4 were added to the extract. Absorbance was read at 420nm for sugar determination. While For the determination of starch, $HCLO_4$ was added to sediment for hydrolysis. The sample was allowed to stand for one hour, and vortexed. An aliquot of 0.95ml of distilled water, 0.5ml phenol and 2.5ml H_2SO_4 were added to 0.05ml of extract and absorbance of sample read at 420nm.

Calculation: The sugar and starch contents were calculated on percentage curve = 0.0055 basis.

$$\% \text{ sugar} = \frac{(A - I) \times D.F \times V \times 100}{B \times W \times 10}$$

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Where: A = Absorbance of sample; I = Intercept of standard curve; D.F =Dilution factor based on aliquot taken for assay, 5 ml = sugar, 20 ml = starch; V = Total extract vol.; 20 ml = sugar, 25ml = starch; B = Slope of the standard curve = 0.0055; W = Weight of sample.

Determination of Cationic Surfactants (Cationic Surface Agents)

This was determined using the titrimetric method of Ibiam *et al* (2016). Exactly 2g of the sample was weighed into a 250 ml beaker, 50ml of distilled was added followed by 5 ml citrate phosphate buffer solution at pH 3.0 and pipetted into the mixture and mixed properly. 30 ml chloroform was added followed by the addition of 2 drops of methyl orange solution which give a yellow colour. The mixture was titrated against 0.010 M sodium tetraphenyl boron solution till a red colour was obtained in the aqueous phase at the end point. The percentage cationic surfactant was calculated using the formula:

$$\% \text{ Cationic Surfactant} = \frac{\text{Titre value x sodium tetraphenyl boron equivalent } 0.01}{\text{Weight of sample taken}} \text{ X } 100$$

Determination of anionic surfactants (anionic surface active agents)

This was determined using the titrimetric method as described by Ibiam *et al*. (2016). Exactly 2.5 g of sample was weighed into a 250 ml beaker; 75 ml of distilled water was warmed slightly and stirred continuously with the entire sample till it dissolves. The mixture was transferred to a 100 ml volumetric flask; the beaker was thoroughly rinsed with distilled water and the water used

for rinsing was added to the beaker to make up to 100 ml mark. Exactly 20 ml of the above was pipetted into 100 ml stoppered measuring cylinder to which 15 ml chloroform and 10 ml of mixed indicator was added to give a pink colour. The overall mixture was titrated against 0.04M Hyamine until the pink colour of the chloroform phase was completely discharged. At this point, the equivalence or end point was reached. The anionic surfactant present was expressed as a percentage using the formula:

$$\% \text{ Anionic Surfactant} = \frac{\text{Titre value x Anionic surfactant x 0.004}}{\text{Weights of sample taken}} \text{ X } 100$$

Determination of total hydrocarbon

The total hydrocarbon was determined using spectrophotometry method described by MERL (1998). 5g of the sample was weighed into a 100ml dust in bottle, 25ml of N- hexane was added and shook for 10 minutes, covered and allowed to stand for 10mins. It was later filtered and absorbance read at a wavelength of 460nm. Also, a total hydrocarbon standard stock (1000 ppm) was then prepared by pipetting 1.18ml of Forcadas blend crude oil and made up to 1litre with N – hexane. Then serial dilution of 0, 10, 20, 40, 60 and 100 ppm working standard were prepared.

$$\text{Total hydrocarbon} = \frac{\text{absorbance x slope x volume}}{\text{Weight of sample taken}}$$

Sensory Evaluation

The sensory evaluation of the produced *fufu dough* was done using completely randomized block design to administer the samples in similar plates each with coded 3-digit non-misleading or biasing numbers to the panel. The samples were then presented to Twenty (20) semi-trained panelist consisting of staff of National Root Crops Research Institute, Umudike. Before the assessment, the meaning of the descriptions was explained and panelists were instructed prior to the exercise. Portable water was served to the panelists to use for rinsing after each testing so as not to interfere with the taste of the preceding samples. The attributes assessed included appearance, odour, taste, draw ability, smoothness and overall acceptability. A nine point Hedonic measure was used for the test as cited by (Iwe, 2002) where 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like slightly, and 9 = like extremely (Appendix 1).

Statistical analysis of data

The statistical software package design 8.07 (stat Inc. Minneapolis, USA) was used to generate the experimental design matrix, analyze the experimental data. A 2-way ANOVA was used to analyze the sensory evaluation.

Results and Discussion

The biochemical Composition of the *fufu* flour samples is presented in Table 1.

Biochemical composition of the fufu mash flour

Amylose Content

The amylose contents ranged from 12.080% (*fufu* with palm ash) to 21.230% (*fufu* control). Sample D (*Fufu* control) had the greatest amylose content (21.230%), while Sample C (*Fufu* with palm ash) had the least amylose content (12.080%), and they are significantly (P>0.05) different from each other. This could be because of the fermentation aids that were present in the *fufu* samples. These values fell within the range reported by Chijioke *et al.* (2016) of values 15.02 to 22.83%. Amylose content is an important determinant of the functional property of flour and starches.

Amylopectin content

The amylopectin content ranged from 78.769% (*fufu* control) to 87.092% (*fufu* with palm ash), and they are significantly (p>0.05) different from each other. This result is in agreement with the ranges 77.1% to 86.02% as reported by Chijioke *et al*. (2016) and also with the findings of Shittu *et al*.(2007), who reported that high amylopectin levels of cassava flours is associated with high expansion.

Free sugar content

The free sugar content ranged from 2.175% (*fufu* with detergent) to 5.215% (*fufu* with kerosene). There was no significant (p<0.05) difference between the sugar content of sample A (*fufu* with detergent) with the value and sugar content of sample C (*fufu* with palm ash), likewise no significant (p<0.05) difference between sugar content of sample B (*Fufu* with kerosene) and sugar content of sample D (*Fufu* control). These values fell within the range reported by Chijioke *et al.* (2016) of values 1.76% to 10.83%.

Starch content

The starch contents ranged from 70.775% (*fufu* with palm ash) to 85.475% (*fufu* control). Sample D (*Fufu* control) had the highest starch content while Sample C (*Fufu* with palm ash) had the least starch content, and they are significantly (P>0.05) different from each other. This could be as a result of the fermentation aids that were present in the *fufu* samples. The values of the starch contents corresponds with the findings of Moorthy *et al*.(1996) who reported starch values between 71% - 90%. The result is also in agreement with the report of (Abass, 1992) that the standard specification for cassava flour in Nigeria is a minimum of 65%.

Surfactant composition of the wet fufu mash and cooked dough samples

The anionic and cationic surfactant values in the wet *fufu* mashes ranged from 0.02mg/l (Sample *fufu* control) to 0.16mg/l (sample *fufu* with detergent) and 0.02mg/l (sample *fufu* control) to 0.22mg/l (sample *fufu* with detergent). There was significant (p>0.05) difference between the *fufu* samples (Table 2). This could be attributed to the level of surfactant present in each of the fermenting aids that were included in the *fufu* samples

during fermentation. According to (Essential chemical industry, 2013), 'Surfactants are one of many different compounds that make up a detergent'. This shows that sample A (*Fufu* with detergent) which contains detergent has anionic and cationic surfactant levels more than the other samples. Also, Tracy (2020) established that palm or coconut tree contains natural surfactants. This may explain why sample C (*Fufu* with palm ash) has a considerable level of anionic and cationic surfactants. The total hydrocarbon values ranged from 0.15mg/l (Sample *fufu* control) to 2.77mg/l (Sample *fufu* with kerosene). There was significant ($p>0.05$) difference between the *fufu* samples. This exists due to the concentration levels of hydrocarbons found in each of the fermentation aids used during the fermentation of the *fufu* samples. Sample B (*Fufu* with kerosene) have higher hydrocarbon level of 2.77mg/l, followed by Sample C (*Fufu* with palm ash) with 1.69mg/l; Sample A (*Fufu* with detergent) with 1.56mg/l and Sample D (*Fufu* control) with 0.15mg/l.

In the cooked *fufu* dough, anionic and cationic surfactant values ranged from 0.01mg/l (Sample *fufu* control) to 0.13mg/l (Sample *fufu* with detergent) and 0.01mg/l (Sample *fufu* control) to 0.16mg/l (Sample *fufu* with detergent). There was significant ($p>0.05$) difference between the *fufu* samples, and this could be attributed to the level of surfactant remaining in the *fufu* samples after heat treatment. The anionic and cationic surfactants present in detergent contains some levels of trace metals like lead, cadmium, zinc and chlorine salts, which are found to be within the body's tolerable limit of 0.2mg/l (WHO/FAO, 2012) both in the wet *fufu* mash and the cooked *fufu* dough, The total hydrocarbon values of the cooked *fufu* dough ranged from 0.12mg/l (Sample *fufu* control) to 1.86mg/l (Sample *fufu* with kerosene). There was significant ($p>0.05$) difference between the *fufu* samples. This could be observed due to the concentration levels of the hydrocarbon in the *fufu* samples after heat treatment. Sample B (*Fufu* with kerosene) have higher hydrocarbon level of 1.86mg/l, followed by Sample C (*Fufu* with palm ash) with 1.44mg/l; Sample A (*Fufu* with detergent) with 1.37mg/l and then Sample D (*Fufu* control) with 0.14mg/l. The Occupational Safety and Health Administration (OSHA) (1995), has set a limit of 0.2 milligrams for body tolerance to PAHs (Policyclic Aromatic Hydrocarbons). The total hydrocarbon contents of the dried *fufu* flour samples as well as the cooked *fufu* dough were observed to be higher than the limit for human consumption except for the *Fufu* control which is below the acceptable limit. This level of hydrocarbon concentration could serve as a risk factor in the consumption of *fufu* produced with these fermentation aids.

Sensory properties of the fufu dough samples

Appearance

The scores for the appearance ranged from 8.70 to 8.85 (Table 3). There was no significant ($p< 0.05$) difference between the appearance of all the *fufu* samples despite the fermentation aids that were added. Appearance is one of the first indicators of quality; it contributes and influences the consumer purchase power and market value.

Odour

The scores for the odour ranged from 8.55 to 8.85. There was no significant ($p< 0.05$) difference between the odour of all the *fufu* samples despite the fermentation aids that were added. This showed that the odour of the *fufu* samples were of acceptable level considering the characteristic putrid odour of *fufu* that is fermented traditionally.

Drawability

The rating for the *fufu* drawability ranged from 8.45 to 8.85. There was no significant ($p< 0.05$) difference between the drawability of all the *fufu* samples. Drawability may be likened to the degree of cohesiveness of the *fufu* paste during cooking. According to Bechoff, *et al*. (2018), cohesiveness, a major textural property that drives consumer acceptance, is linked to starch composition especially amylose content. Numfor (1999) and Rosales-soto *et al*., (2016) findings also show that cohesiveness in cassava paste is associated with intermolecular forces within the food, and failure of starch granules to release sufficient amylose. This leads to reduction in cohesiveness of fermented cassava product. Furthermore, Dufour *et al.* (2002) reported that presence of fibre can reduce the cohesiveness of cassava paste. These textural and pasting characteristics of starch have been associated with cooking quality and texture of various food products (Otegbayo *et al*., 2006). Therefore, drawability of the *fufu* may have a link with the retting ability of the cassava roots.

Smoothness

The rating for the *fufu* smoothness ranged from 8.50 to 8.85. There was no significant ($p< 0.05$) difference between the smoothness of all the *fufu* samples. Bechoff *et al*. (2018) described smooth *fufu* as dough that is homogeneous in appearance and hand-feel, and does not have notable fibres, lumps or particles. The author goes ahead to say that *fufu* smoothness is enhanced by the removal of fibre during the sieving operation of fermented roots or mash. This goes ahead to support the report by Uyoh *et al*. (2009) who stated that insoluble fibres are disintegrated by cellulolytic and pectinolytic enzymes activities during retting, hence enhancing efficiency of sieving and smoothness of *fufu*. This finding suggests that smoothness of *fufu* may be correlated with the fibre content of the fresh cassava root. This shows that the *fufu* samples were well removed of fibres during sieving which gave it an acceptable smoothness.

Taste

From the result, the scores for the taste of the *fufu* samples ranged from 8.40 to 8.85. There was no significant ($p< 0.05$) difference between the taste of all the *fufu* samples despite the inclusion of fermentation aids. This could be as a result of the heat which the *fufu* starch have undergone. According to Chou *et al*.,

(2012), heating is an important step for preparing starch-based products, as heating affects the quality of the products due to gelatinization and degradation of the starch.

Overall acceptance

The overall acceptance rating ranged from 9.10-9.20. There was no significant (*p> 0.05)* difference among all the samples analysed. This study shows that the fermentation aids added to the *fufu* during fermentation significantly did not affect the sensory properties of the *fufu* samples; hence, the panelists generally accepted the *fufu* samples.

Conclusion

This research work has studied the quality of *fufu* produced with different fermentation aids. The results have shown the presence and levels of cationic and anionic surfactants as well as hydrocarbons present in the wet mashes and dough of the *fufu* produced. In as much as the surfactant levels observed were below the permissible limits, the toxicity effect of these chemicals even the hydrocarbon present on human health cannot be over emphasized. Their usage as fermentation agents should be highly discouraged as their accumulation in the body system over time results in toxicity thereby creating serious health hazards, which are detrimental to human health. Dissemination of the result of this research work should be encouraged, and this would be through workshops, seminars and symposium especially to the rural people. Also, research on the alternate safer way of cassava fermentation for *fufu* production that will give these processors good *fufu* yield should be carried out thoroughly.

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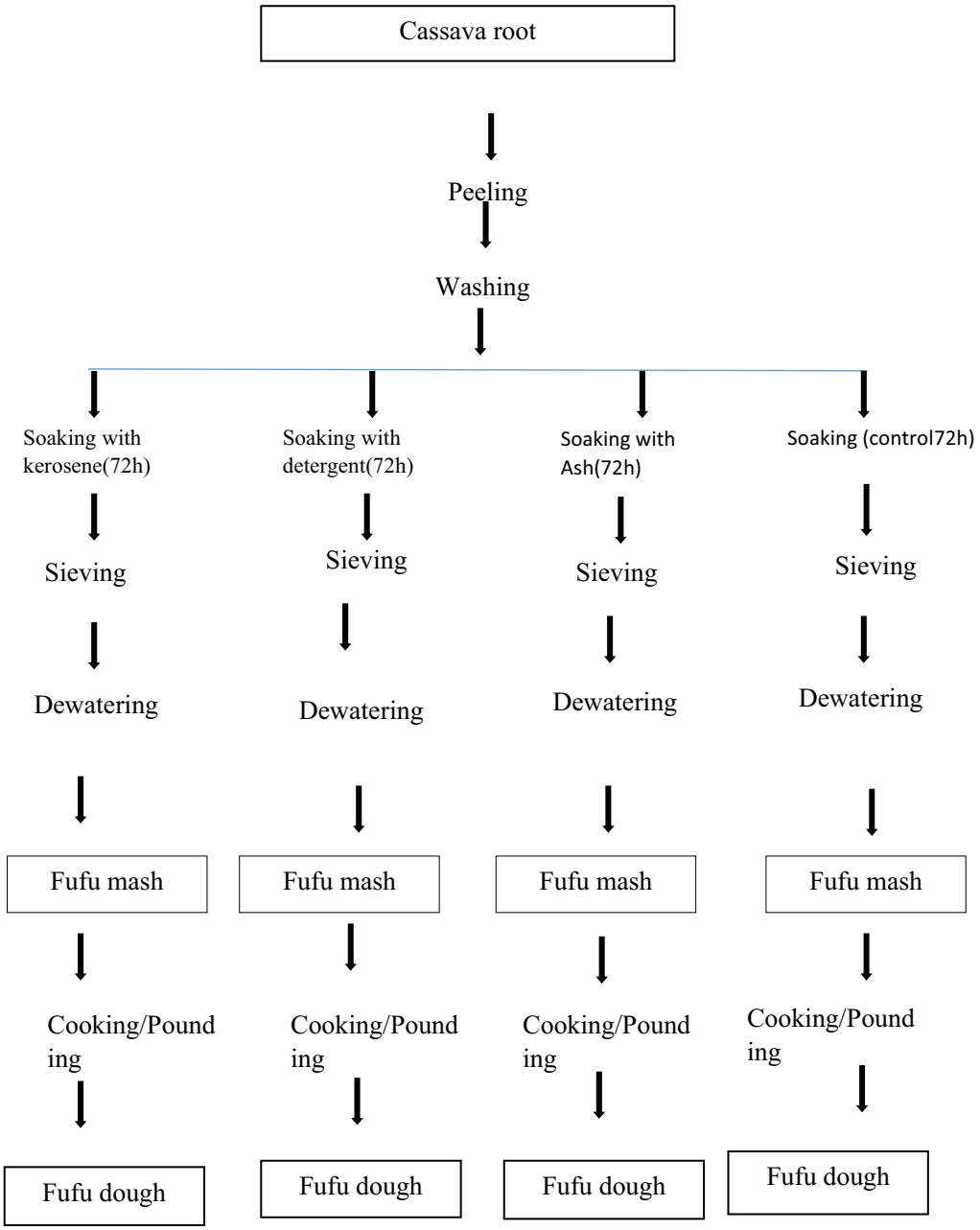

Figure 1: The flow Chart of the production of fufu mash and dough

Table 1: Biochemical composition of the *fufu* mash flour

Samples	Amylose (%)	Amylopectin (%)	Free sugar (%)	Starch (%)
A	$15.492^{b}\pm0.01$	$84.507^{a}\pm0.01$	$2.175^{b}\pm0.01$	$80.525^{c}\pm0.01$
B	$13.620^{c}\pm0.01$	$86.379^{b}\pm0.01$	$5.215^{a}\pm0.01$	$75.745^{b}\pm0.01$
C	$12.080^{d}\pm0.01$	$87.092^{c}\pm0.01$	$3.165^{b}\pm0.01$	$70.775^{a}\pm0.01$
D	$21.230^{a}\pm0.01$	$78.769^{d}\pm0.01$	$4.205^{a}\pm0.01$	$85.475^{d}\pm0.01$
LSD	**0.0196**	**0.0196**	**0.0196**	**0.0196**
CV (%)	**2.773**	**0.0071**	**3.7216**	**1.1224**

Note: values are means of duplicate determinations. Means with different superscripts are significantly different at (p > 0.05)
Key: A = Fufu with detergent, B = Fufu with kerosene, C = Fufu with palm ash, D = Fufu Control

Table 2: Surfactant composition of the wet *fufu* mash and cooked dough samples

Samples	Anionic surfactant (mg/l)	Cationic surfactant (mg/l)	Total Hydrocarbon (mg/l)	Anionic surfactant (mg/l)	Cationic surfactant (mg/l)	Total Hydrocarbon (mg/l)
		Wet *Fufu* Mash			**Cooked *Fufu***	
A	$0.16^{a}\pm0.00$	$0.18^{a}\pm0.00$	$1.56^{a}\pm0.01$	$0.13^{a}\pm0.00$	$0.16^{a}\pm0.00$	$1.37^{a}\pm0.00$
B	$0.05^{c}\pm0.00$	$0.07^{c}\pm0.00$	$2.77^{c}\pm0.00$	$0.04^{b}\pm0.00$	$0.05^{c}\pm0.00$	$1.86^{c}\pm0.01$
C	$0.12^{b}\pm0.00$	$0.16^{b}\pm0.00$	$1.69^{b}\pm0.01$	$0.06^{c}\pm0.00$	$0.13^{b}\pm0.00$	$1.44^{b}\pm0.02$
D	$0.02^{d}\pm0.00$	$0.02^{d}\pm0.00$	$0.15^{d}\pm0.01$	$0.01^{d}\pm0.00$	$0.01^{d}\pm0.00$	$0.12^{d}\pm0.01$
LSD	0.00196324	0.003539287	0.02944865	0.002597127	0.00310416	0.04047329
CV (%)	0.7197016	0.9486548	0.6082639	1.505697	1.028077	1.131125

Note: values are means of duplicate determinations. Means with different superscripts are significantly different at (p > 0.05).
Key: A = Fufu with detergent, B = Fufu with kerosene, C = Fufu with palm ash, D = Fufu Control

Table 3: Sensory Properties of the *fufu* dough samples

Samples	Appearance	Odour	Drawability	Smoothness	Taste	OA
PalmAsh	$8.83^{a}\pm0.42$	$8.80^{a}\pm0.41$	$8.75^{a}\pm0.44$	$8.75^{a}\pm0.44$	$8.85^{a}\pm0.37$	$9.20^{a}\pm0.00$
Control	$8.75^{a}\pm0.44$	$8.85^{a}\pm0.37$	$8.85^{a}\pm0.37$	$8.85^{a}\pm0.37$	$8.85^{a}\pm0.37$	$9.20^{a}\pm0.00$
Detergent	$8.85^{a}\pm0.37$	$8.65^{a}\pm0.59$	$8.55^{a}\pm0.60$	$8.70^{a}\pm0.47$	$8.55^{ab}\pm0.51$	$9.10^{a}\pm0.47$
Kerosene	$8.70^{a}\pm0.40$	$8.55^{a}\pm0.60$	$8.45^{a}\pm0.76$	$8.50^{a}\pm0.76$	$8.40^{b}\pm0.75$	$9.15^{a}\pm0.69$
LSD	**Ns**	**ns**	**ns**	**Ns**	**0.3299**	
CV (%)	**6.25**	**5.78**	**6.52**	**6.11**	**6.05**	**0.2625**
						4.74

Note: values are means of duplicate determinations. Means with different superscripts are significantly different at (p > 0.05).
Key: OA = Overall Acceptability, ns = Not significan