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Evaluation of Mineral, Vitamin and Sensory Quality Characteristics of African Breadfruit-Corn Milk

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ABSTRACT

African breadfruit-corn milk was subjected to mineral, vitamin and sensory evaluation using very popular plant milk (soymilk) as a control. The contribution effect of the constituent corn milk and breadfruit milk was positive in both nutrient and sensory attributes. The African breadfruit-corn milk was significantly ($p<0.05$) higher than the soymilk in sodium, calcium, potassium, magnesium, manganese, iron and zinc, while the soymilk was significantly ($p<0.05$) higher in copper. The breadfruit-corn milk was also significantly ($p<0.05$) higher in vitamin A, vitamin B_2 and vitamin $B_{3,}$ while the soymilk was significantly ($p<0.05$) higher in vitamin C. There was no significant ($p>0.05$) difference in vitamin B_1 content of the two milk samples. Sensory acceptability test showed that there were no significant ($p>0.05$) differences in color, texture, taste, aroma and overall acceptability of breadfruit milk and soymilk, suggesting that African breadfruit-corn milk can be the good substitute for soymilk.

Key words: Breadfruit -Corn Milk, Soymilk, Mineral, Vitamin, Sensory Quality Characteristics.

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1 INTRODUCTION

Milk is an emulsion or colloid of butter fat globules that contains dissolved carbohydrate and protein with water-based fluid. Milk can be synthesized in a laboratory from water, fatty acids and proteins. The term milk is also used for white coloured non-animal beverage resembling milk in colour and texture (milk substitutes) such as soymilk, rice milk, almond milk and coconut milk (Olivia, 2014).

The value of milk in relieving malnutrition, especially among the growing infant in developing countries is particularly noteworthy, but the cost of dairy milk and their products are expensive for commoners to purchase (Adedokun et al., 2014). It was reported in 2007 that with increased worldwide prosperity and competition of bio fuel production for feed stocks, both the demand for and the price of milk had substantially increased worldwide. Particularly notable was the rapid increase in consumption of milk in China and the rise of the price of milk in the United States above government subsidized price (Wayne, 2007). Although economic growth has increased the demand for food of animal origin, the cost of dairy product has restricted their consumption to the more affluent (FAO, 2009; Ghandi and Zhou, 2010). An inexpensive substitute in the form of a milk or beverage made from locally available plant food high in protein, with satisfactory quality, could play an important role to reduce protein malnutrition (Ukwuru and Ogbodo, 2011).

The general term for any milk-like product that is derived from a plant is called plant milk (Okorie et al., 2014). Plant milk have been a century aged drink both as regular drinks (such as the Spanish horchata) and as a substitute for milk, such as by some Christian denomination during lent. The most popular varieties internationally are soymilk, almond milk, rice milk and coconut milk (Esperly, 2008). Milk substitute has been recently produced from corn (Supavititpatana et al., 2010). Nwakalor (2014) investigated the effect of storage on the microbiological quality of formulated African breadfruit beverage. Unlike the soybean, information on use of African breadfruit seeds in milk production is limited. A blend of legume and cereal is considered a nutritionally balanced product (Olakunle, 2012). Products such as soy-corn milk (Omueti and Ajomale, 2005; Kolapo and Oladimeji; 2008) and tiger nut-soy milk (Udeozor, 2012) are examples of such milk blend.

In view of the high nutritional value of African breadfruit seeds (Ekpenyong, 1983; Akubor et al., 2007), it is expected that blending the milk with corn milk will yield acceptable nutritive and sensorial product as in soy-corn milk and tiger nut-soymilk, thereby assisting in the struggle to curb the menace of protein calorie malnutrition among the rural populace, in addition to adding value to these agricultural materials.

2 MATERIALS AND METHOD

2.1 Source of Materials

The African breadfruit seeds and the soybean seeds were purchased from Oye-Agu Market Abagana, Njikoka L.G.A., Anambra State, Nigeria.

The sweet corn was purchased from Songhai Farm Initiative, Heneke, Ezeagu L.G.A., Enugu State, Nigeria.

2.2.1 Production of Milk Samples

The milk samples were prepared shortly after procurement of raw materials.

2.2.2 Production of breadfruit milk

The African breadfruit seeds were hulled using the method of Onweluzo and Nnamuchi (2009). The seeds were washed in excess volume of water to remove extraneous materials and immature seeds, drained and parboiled in water at 95^{0}C for 15 min with constant stirring. The parboiled seeds were drained; air dried and hulled in a hand mill (Corona, Landers YCIA, South Africa) whose teeth gap was adjusted to approximately 15 mm to crack the hull without crushing the seeds. This was winnowed to remove the hulls, sorted to remove unwholesome seeds and preserved for subsequent use.

Extraction of milk followed the method of Onweluzo and Nwakalor (2009) with modification. Exactly 1 kg of hulled breadfruit seeds was washed before soaking in potable water for 6 h, with soak water replaced every 2 h to avoid fermentation and to reduce foul odour and greasy substances, thereby providing clean and tender seeds. The seeds were repeatedly washed, rinsed with distilled water and wet-milled in a variable speed blender (SB-736, Sonic, Japan), with intermittent addition of distilled water. The slurry was filtered through double layer linen cloth and the residue was wet-milled twice more for maximum juice extraction, with final seeds to water ratio of 1:3 (w/v). The filtrate was boiled for 20 min with continuous stirring, re-filtered to obtain plain breadfruit milk as in Fig. 1.

2.2.3 Production of corn milk

Preparation of corn grains followed the method of Ihekoronye and Ngoddy (1985). The green field sweet corn was firstly husked, the silks removed and washed with water. The grains were separated from the cob using knife, cleaned to remove hairs and other extraneous materials to obtain clean grains. Milk extraction followed the method of Supavititpatana et al. (2010) with modification. Exactly 1 kg of clean grains was soaked in potable water for 6 h with soak water replaced every 2 h to avoid fermentation. This was repeatedly washed, rinsed with distilled water and wet-milled in a variable speed blender with intermittent addition of distilled water as before. The slurry was filtered through double layer linen cloth and the residue was wet-milled twice more for maximum juice extraction, giving final grain to water ratio of 1:3 (w/v). The filtrate was boiled for 15 min, re-filtered to give plain corn milk as in Fig. 2.

2.2.4 Production of breadfruit-corn milk

Portions of plain breadfruit milk and plain corn milk previously produced were blended on breadfruit milk: corn milk ratio of 60:40 (v/v). The plain milk samples were formulated by adding emulsifier (0.02% glyceryl monostearate), stabilizer (0.02% carrageenan), sweetener (2% sucrose), which was not added to the corn milk due to the characteristic sweet taste of sweet corn. preservatives (0.01% potassium sorbate and 0.01% sodium benzoate) and milk flavouring (to taste). This was homogenized in a 5–speed hand mixer (MC – HM 6630 Master Chef and Crown Star, China), pasteurized at 65^{0}C for 15 min, hot-filled into sterile 250 ml screw capped plastic bottles, rapidly cooled and stored at ambient condition**.**

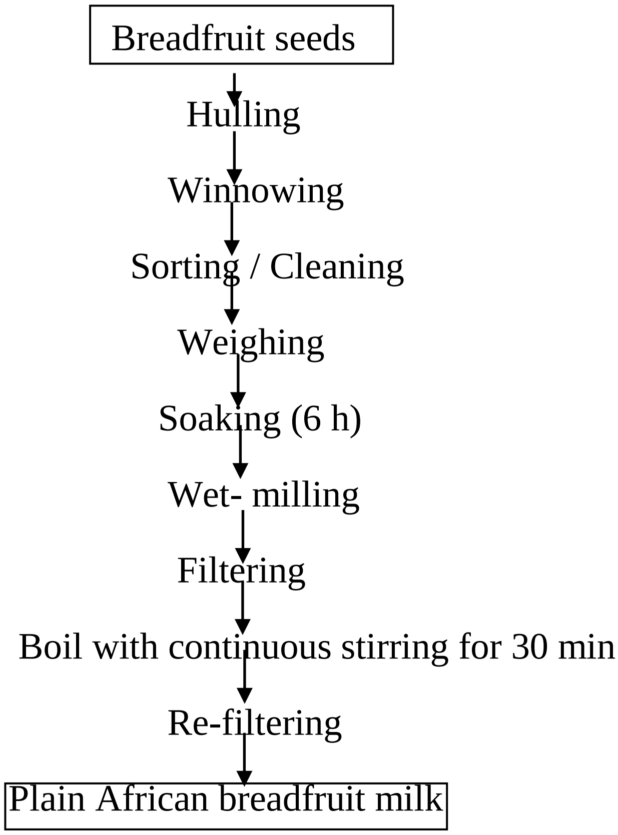

Fig.1: Flow chart for the production of plain African breadfruit milk

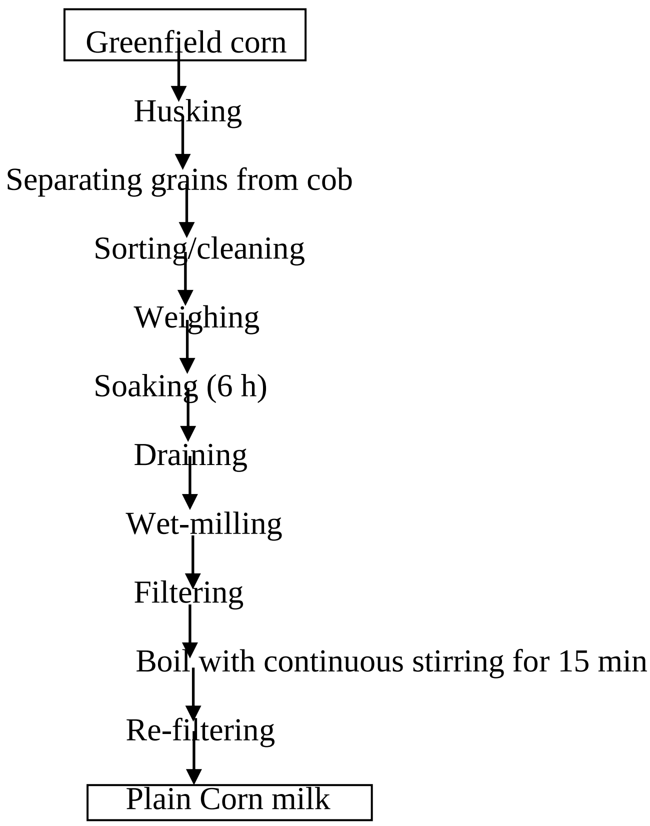

Fig.2: Flow chart for the production of Plain Corn milk

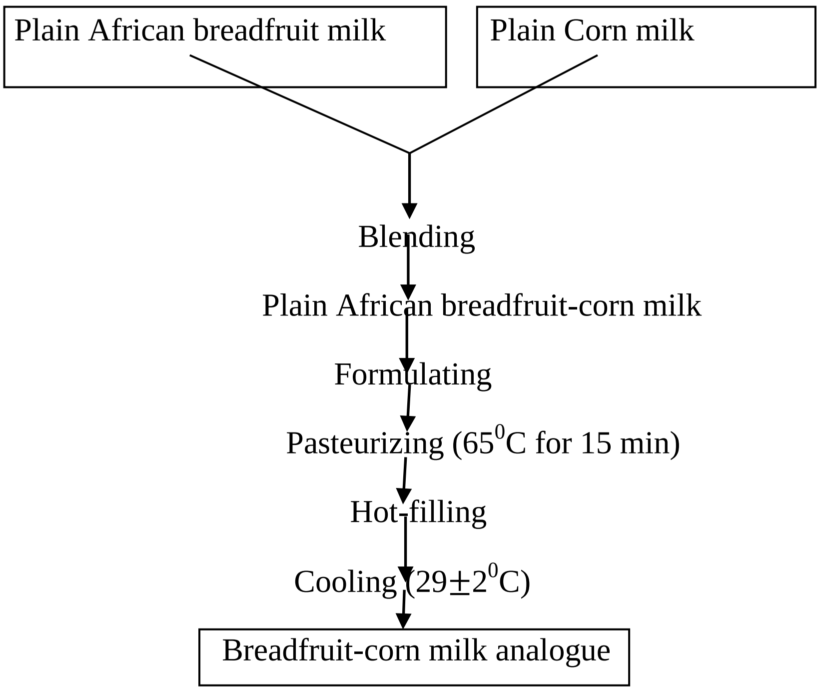

Fig.3: Flow chart for the production of African breadfruit-corn milk

2.2.5 Production of soymilk

The soybean seeds were prepared using the method of Trisnawati et al. (2013). The seeds were sorted and washed, soaked in excess volume of water for 8 h, decanted and boiled for 30 min. The grains were threshed out and washed repeatedly to obtain clean cotyledons.

The method of Udeozor (2012) was used to extract the soymilk. The clean cotyledons were not further soaked as the earlier soaking sufficed. Exactly 1 kg of cotyledons was repeatedly washed, rinsed with distilled water and wet-milled in a variable speed blender with intermittent addition of distilled water as before. The slurry was filtered through double layer linen cloth and the residue was wet-milled twice more for maximum juice extraction, yielding final bean to water ratio of 1:3 (w/v). The filtrate was boiled for 20 min, re-filtered to obtain plain soymilk. The plain soymilk was formulated with emulsifier (0.1% glycerly monostearate), stabilizer (0.1% carregeenan), milk flavour (to taste), preservatives (0.01% sodium benzoate and 0.01% potassium sorbate) and sweetener (2% sucrose).

2.3 MINERALS AND VITAMINS ANALYSIS

2.3.1. Determination of minerals

Mineral analysis was conducted using Varian AA240 Atomic Spectrophotometer (AAS) according to the method of APHA (1995). Approximately 2 g of the sample was weighed into a digestion flask and 20 ml of the acid mixture (650 ml conc. $HNO_{3,}$ 80 ml perchloric acid, 20 ml Conc. H_2S0_4) was added. The flask was heated until a clear digest was obtained. The digest was diluted with distilled water to 100 ml mark. Appropriate dilutions were then made for each element. A series of standard metal solution in the optimum concentration range were prepared daily by diluting the single stock element solutions with water containing 1.5 ml concentrated nitric acid/liter. A calibration blank was prepared using all the reagents except for the metal stock solutions. Calibration curve for each metal was prepared by plotting the absorbance of standard versus their concentrations.

2.3.2 Determination of Vitamins

Vitamin A

Vitamin A was determined by the calorimetric method of Kirk and Sawyer (1991). Approximately 1 g of the sample and standard were mixed with 30 ml of absolute alcohol and 3 ml of 5% KOH solution was added to it and was boiled for 30 min under reflux. After washing with distilled water, vitamin A was extracted with 150ml of diethyl ether. The extract was evaporated to dryness at low temperature and then dissolved in 10 ml of isopropyl alcohol. Exactly 1 ml of standard Vitamin A solution was prepared and that of the dissolved extract were transferred to separate cuvettes and their respective absorbance were read in a spectrophotometer at 325 nm with a reagent blank at zero.

Conc. of Vitamin A in Sample = $\frac{\text{Abs of Sample}}{\text{Abs of Std}}$ x conc. of std

Vitamin B_1 and B_2

Approximately 1 g of sample was weighed into a conical flask and was dissolved with 100 ml of deionized water. This was shaken thoroughly and heated for 5 min and allowed to cool and then filtered. The filtrate was poured into cuvettes and their respective wavelengths for the vitamins set to read the absorbance using spectrophotometer.

Vitamin B_1 = 261nm

Vitamin B_2 = 242nm

Vitamin conc. (mg/%) = $\frac{\text{AXD.FX Vol. of cuvette (5)}}{\text{E}}$

Where A = Absorbance

E = Extinction co-efficient = 25 for B_1 and B_2

DF = Dilution factor

Vitamin B_3

This was determined by titrimetric method of Kirk and Sawyer (1991)

Approximately 5 g of sample was dissolved in 20 ml of anhydrous glacial acetic acid and warmed slightly. About 5 ml of acetic anhydride was added and mixed. Two to three drops of crystal violet solution was added as indicator. O.1M perchloric acid was added to titrate to a greenish blue colour.

Vitamin B_3 = $\frac{\text{titre value x 0.012}}{0.1}$

Vitamin C

This was determined by titrimetric method of Kirk and Sawyer (1991).

Approximately 2g sample was homogenized in 6% EDTA/TCA solution. The homogenate was filtered and used for analysis. 20 ml of 30% KI solution was added to it and was titrated against O.IM $CUSO_4$ solution. The end point was marked by a black coloration. A reagent blank was also titrated.

Vitamin C content was calculated based on the relationship below:

1ml of 0.1mole $Cus0_4$ = 0.888mg vitamin C

Vitamin C = $\frac{\text{100 x 0.88 (titre−blank)}}{\text{Weight of sample}}$

2.4 SENSORY QUALITY EVALUATION

Coded milk samples were presented in similar form to a 30 member sensory panel who were requested to rate the milk samples in terms of colour, texture, taste, aroma and overall acceptability on a 9-point hedonic scale where I = dislike extremely and 9 = like extremely (Iwe, 2014). Each panelist was provided with enough privacy to avoid biased assessment.

2.5 STATISTICAL ANALYSIS

Triplicate results of samples obtained were subjected to analysis using SPSS version 17. One-way analysis of variance (ANOVA) was performed for multiple samples and the differences between mean values were evaluated at $p<0.05$ using Post Hoc Multiple Comparison Test.

3 RESULTS AND DISCUSSION

Table 1: Mineral content of milk samples

Parameter	CMA	BMA	BCM	SMA
Sodium (ppm)	5.187[a]±0.02	3.888[d]±0.02	4.859[b]±0.01	4.489[c]±0.11
Calcium	16.939[a]±0.62	14.691[d]±0.11	16.562[b]±0.06	15.582[c]±0.06
Potassium	3.142[d]±0.06	14.647[a]±0.04	8.487[b]±0.02	7.447[c]±0.06
Magnesium	12.789[a]±0.01	3.200[d]±0.01	5.954[b]±0.06	5.492[c]±0.01
Manganese	0.015[d]±0.01	0.028[a]±0.00	0.022[b]±0.00	0.016[c]±0.00
Iron	0.034[c]±0.01	0.039[a]±0.00	0.038[b]±0.00	0.031[d]±0.00
Copper	0.026[d]±0.00	0.034[b]±0.00	0.029[c]±0.00	0.052[a]±0.00
Zinc	0.027[d]±0.00	0.036[a]±0.00	0.032[b]±0.00	0.028[c]±0.00

Means within a row followed by different superscripts are significantly (p<0.05) different. CMA=Corn milk, BMA=Breadfruit milk, BCM=Breadfruit-corn milk, SMA=Soymilk

3.1 Minerals

There was significant ($p < 0.05$) difference in mineral contents of the milk samples. The improvement in the mineral values of breadfruit-corn milk, as evident in Table 1, was an indication of positive contribution effect of corn milk and breadfruit milk. The breadfruit-corn milk was significantly ($p<0.05$) higher than the soymilk (control) in every other mineral tested except for copper, where the soymilk was significantly ($p<0.05$) higher. The high mineral content of breadfruit-corn milk is understandable since corn and breadfruit are good sources of minerals. The high content of minerals in corn milk and breadfruit milk blended to give good balance of mineral elements of breadfruit-corn milk. The values obtained in this study were higher than the 0.38 to 0.45 mg/100ml for breadfruit milk and 0.47mg/100ml for soymilk reported by Onweluzo and Nwakalor (2009). The difference in values may be due to extraction method, the ratio of extractant to the seeds or meal, and the levels of these minerals in the seeds. Like the values reported by several researchers on other vegetable milks, the mineral contents were lower when compared with standards recommended for dairy whole milk (120mg/100g calcium, 87mg/100g potassium, 880mg/100g Iron, 7mg/100g Zinc) by the International Dairy Federation (IDF, 2008), except for the magnesium. Vegetable milk preparation is usually fortified with calcium and iron salts. Calcium level can be augmented through controlled fortification that will not induce instability problems, particularly with regards to protein content (Rasyid and Hansen, 1991). Onyeka (2008) reported that mineral elements are inorganics that are found in traces and play important roles in human nutrition and their inadequacy may result to nutritional disorder in human body. It is therefore imperative to fortify milk analogues with minerals to meet the desired requirement.

Table 2: Vitamin content of milk samples

Parameter	CMA	BMA	BCM	SMA
Vitamin A (mg/g)	56.760[a]±0.04	37.716[d]±0.08	48.866[b] ±0.12	39.523[c]±0.07
Vitamin B_1 (mg/%)	1.602[a]±0.01	1.510[c]±0.00	1.560[b]±0.00	1.565[b]±0.00
Vitamin B_2 (mg/%)	1.887[c] ±0.01	2.177[a]±0.01	2.021[b]±0.01	1.540[d]±0.02
Vitamin B_3 (mg/%)	1.465[c]±0.04	1.601[a]±0.06	1.577[b] ±0.06	1.085[d]±0.02
Vitamin C (mg/l)	32.020[d]±0.02	38.850[b]±0.14	36.600[c]±0.03	51.993[a]±0.28

Means within a row followed by different superscripts are significantly (p<0.05) different.

3.2 Vitamins

As shown in Table 2 the breadfruit-corn milk was significantly ($p<0.05$) higher in vitamin A, B_2 and B_3 than the soymilk but was significantly lower in vitamin C. There was no significant difference in vitamin B_1. The higher value of vitamin A in the breadfruit-corn milk could be due to high carotene content of sweet corn used in the milk blend. The yellow colour of yellow corn is induced by xanthophylls pigment (carotenoids) which are vitamin A precursor (Floyd and Brandon, 1995). This agrees with the report of Omueti and Ajomale (2005) that high carotene level of yellow corn will result in increased level of vitamin A in corn based beverages. The higher content of vitamins B_2 and B_3 could be attributed to their levels in the raw materials used. Sweet corn provides all the B vitamins except B_{12} and its addition to the breadfruit-corn milk might have improved the values of these B vitamins. Water soluble vitamins are susceptible to process loss. Olapade and Umeonuorah (2013) reported significant ($p<0.05$) difference in vitamin A, B_1, B_2, B_3 and C content of raw and processed samples due to effect of processing methods. Badejo (1999) reported that loss of vitamins occur during processing operations as milling, soaking, trimming and blanching. Short soaking period and mild temperature treatment was adopted in this study to minimize such process losses. The higher vitamin C content of soymilk is in accord with earlier reports of Onweluzo and Nwakalor (2009) of higher value of vitamin C in soymilk than in breadfruit milk. The vitamin C content of soymilk of 5.19mg/100ml was higher than the 4.2mg/100ml reported by Onweluzo and Nwakalor (2009). The difference may be due to processing method. Water soluble vitamins are susceptible to process losses. Badejo (1999) reported that loss of vitamins occur during processing operations such as milling, soaking, trimming and blanching. The vitamin C content of the breadfruit-corn milk was however higher than the 2.0mg/100ml level in dairy milk. This is understandable because vitamin C is synthesized primarily by plants

3.3 Sensory scores

Table 3: Sensory scores of milk samples

Attributes	CMA	BMA	BCM	SMA
Color	$6.76^{ns}\pm0.65$	$6.76^{ns}\pm0.62$	$6.80^{ns}\pm0.82$	$7.23^{ns}\pm0.68$
Texture	$5.96^{c}\pm1.04$	$6.13^{b}\pm0.99$	$6.33^{a}\pm0.82$	$6.80^{a}\pm0.62$
Taste	$5.98^{b}\pm0.93$	$6.20^{a}\pm0.86$	$6.46^{a}\pm0.88$	$6.70^{a}\pm0.86$
Aroma	$6.10^{ns}\pm1.27$	$6.20^{ns}\pm0.79$	$6.36^{ns}\pm0.62$	$6.43^{ns}\pm0.64$
Overall acceptability	$6.11^{ns}\pm0.89$	$6.18^{ns}\pm0.65$	$6.38^{ns}0.93$	$6.72^{ns}\pm1.16$

Means within a row followed by different superscripts are significantly ($p<0.05$) different. Ns= no significant difference.

From the result of the sensory evaluation of milk samples (Table 3) there was no significant ($p>0.05$) difference in the colour of milk samples. There was no significant ($p>0.05$) difference in the texture of the breadfruit-corn milk and the soymilk. The texture of corn milk was significantly ($p<0.05$) different from the other milk samples. The higher level of suspended solids in the corn milk might have influenced the lower texture appeal. Nelson et al. (1976) reported similar affect in products with high levels of suspended solids. There was no significant ($p>0.05$) difference in taste of the breadfruit milk, breadfruit-corn milk and the soymilk, while the corn milk tasted significantly ($p<0.05$) lower than the rest. The higher apparent viscosity of corn milk might have affected the taste and mouth feel, which corroborates earlier reports of Onweluzo and Nwakalor (2009) on organoleptic impact of viscosity of beverages. Furthermore, since fat is known to promote good mouth feel (Mustakas, 1974), it is possible that the higher fat content of the soymilk may have influenced the higher taste scores. Also the acidic nature of the maize protein (Hosney, 1994) might have contributed to the low taste score. There was no significant ($p>0.05$) difference in aroma as the samples only varied marginally, with soymilk having the highest score. The preferred aroma of the soymilk might be due to treatment method that minimized the characteristic beany flavour of soy products. There was no significant ($p>0.05$) difference in overall acceptability of the milk samples, though the soymilk received highest acceptance.
In all, the sensory scores revealed that there was no significant ($p>0.05$) difference in colour, texture, taste, aroma and overall acceptability of the breadfruit-corn milk and soymilk samples. The higher values of the soymilk in virtually all the attributes may be due to long time familiarity (Udeozor, 2012). However, the milk sample were acceptable because the mean score of the sensory attributes were above 4.5 (Onweluzo and Nwakalor, 2009).

4. CONCLUSION

This study showed that good quality milk analogue can be obtained by blending breadfruit milk and corn milk. The positive contribution effects of each single extract was evident in the enhanced nutrient and sensory values of the milk blend, which compared closely with soymilk, a very familiar milk of plant origin.
Given that the product was derived from legume and cereal, it could offer the desired dietary balance required for good body upkeep. It therefore calls for more research on the use of African breadfruit and corn to provide another variety of plant milk on a commercial level.

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