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Full Length Research Paper

Centesimal composition and bioactive compounds in African *mustards* used as condiments in Ivory Coast

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The aim of this research was to evaluate the potential of African locust bean *mustard*, produced with fermented *Parkia biglobosa* seed and *Glycine max* seed, as functional food, focusing on its incorporation into the diet. These *mustards* contained in iron and zinc are respectively 12.16±0.63 mg/100 g and 8.38±0.3 mg/100 g in African locust bean *mustard*, and respectively 7 87±0.45 mg/100 g and 4.26±1.07 mg/100 g in soy *mustard*. Polyphenols and flavonoids were contained in large amounts. Ascorbic acid content was, respectively, 19.31 mg/100g of African locust bean *mustard* and 13.26 mg/100 g of soybean *mustard.* However, total carotenoids were 60.72±5.06 mg/100 g of African locust bean *mustard* and 100.86±8.45 mg/100g of soybean *mustard*. The lipid fraction contained unsaturated fatty acids in large amounts. Based on the results obtained, it can be said that West African *mustards* are excellent sources of vegetable proteins, iron, zinc, ascorbic acid, total carotenoids and oils rich in unsaturated fatty acids. These condiments may contain bioactive compounds with functional activities, but further research is needed to assess such potential.

Key words: Mustard, functional food; bioactive compounds.

INTRODUCTION

In the West African region, highly concentrated plant biodiversity sources such as the *Parkia biglobosa* (African locust bean) with innumerable functional properties can be found. However, many of those sources are still unknown.

Parkia biglobosa is a multipurpose fodder tree up to 20 m tall. The fruit pods are dark brown and contain up to 30 seeds called African locust bean. Many vernacular names (nere tree, ahwa, ewé, igba, igiougba, ogba) are used by the local populations. All of the different parts of this plant are used by traditional healers to cure many disorders like hypertension, hemorrhages and dermatosis (Odetola et al., 2006; GrØnhaug et al., 2008; Udobi and Onaolapo, 2009).

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Phytochemical studies have demonstrated the presence of known sterols and triterpenes from the petroleum extract (Tringali et al., 2000). The fermented seeds are well appreciated as a condiment in cooking under various names (for example,, afitin in Benin, nététou in Senegal, dawadawa in Nigeria), being rich in proteins, sugars and vitamin B2 (Azokpota et al., 2006).
Instead of nutritional interest of African locust bean *mustard*, soybean (*Glycine max*) was used as an interesting legume eligible for production of the *mustard*, as a way of diversification and to cater for the unavailability of *Parkia biglobosa* seeds. Soy characteristics are indisputable today. Its proteins are well balanced in amino acids whose amounts are very close for standards recommended by Food and Agriculture Organization (FAO) (Lamboni et al., 1999). African locust beans can be substituted by soybean to manufacture *mustard*.

However, being an important supplement to human diet and/or for their fundamental role in the prevention and treatment of some diseases, the nutritional quality of African locust bean *mustard* is very important. However, diet particularly rich in vegetables and fruits is also recognized as part of a healthy lifestyle, and can lead to reduction of some diseases, and some types of cancer including lung, colon, esophagus, and stomach cancer. Although the mechanisms associated with the reduction of the incidence of these diseases are still not completely clarified, it is known that these diets are usually poor in saturated fats and rich in fibers and various vitamins and minerals. The foods which either prevent or minimize chronic and degenerative diseases, in addition to their role to a good nutrition, are called functional foods (Pourchet-Campos, 1998). They have drawn the public opinion attention due to the health benefits they bring. In the interest of preserving food identity and enhancement of African locust bean *mustards* from Ivory Coast, this study was conducted to evaluate, by analytical determinations, the proximate composition and bioactive compounds of the African locust bean *mustard* and soybean *mustard*. Providing nutritional information about these can be an incentive to the population to include these products in their diets which can help prevent or minimize the incidence of certain diseases.

MATERIALS AND METHODS

All samples were obtained from the “Grand Marché d’Adjamé” (Abidjan, Ivory Coast). African locust bean seed based “mustard” samples used were produced in Korhogo (in the northern, Ivory Coast). Three batches of these “mustard”, 507.66±10.34 g average weight were purchased from each of eight sellers in this market. All soybean based “mustard” used came from Burkina Faso. Three batches of samples of these soybean based “mustard”, 457.16±13.58 g average weight, were purchased from each of the six wholesale sellers. Each batch of “soumbara” cost 500 CFA. Samples purchased on the same day, were brought to the Food Analysis and Processing laboratory at Nangui Abrogoua University (Abidjan, Ivory Coast), where they were subsequently divided into three portions for each sample type (nere seed based “mustard or soybean based “mustard”), with batches purchased from each of the sellers. Each portion, after being homogenized and hermetically sealed, was stored at -20 °C until analysis.

Analysis

All determinations were carried out in triplicate. Moisture content was determined gravimetrically in an oven at 105°C until a stable weight was obtained (AOAC, 1995). The results were shown in grams of moisture per 100 g of fresh sample. The extraction of the lipid fraction was carried out using a Soxhlet Tecator in accordance to Association of Official Agricultural Chemists (AOAC) method (AOAC, 1995). The results were shown in grams of total lipids per 100 g of fresh sample. The total nitrogen determination was carried out using the Kjeldahl method (AOAC, 1995). Total protein was calculated by multiplying the total nitrogen by 6.25, the conversion factor calculated from the amino acid of total sample. The results were expressed in grams of total protein per 100 g of fresh sample.
The total carbohydrate content was obtained by the difference of protein, moisture, lipid and expressing the sum in grams of total carbohydrates/100 g of fresh sample.Total ash content was determined by previous carbonization of the dry samples followed by incineration in an oven at 550 °C (AOAC, 1995). The results were expressed in grams of total ash/ 100 g of sample. The total mineral content was determined from dry samples oxidised in a muffle furnace at 550°C from a minimum period of 2 h followed by acid digestion (HCl, 2 mol/L), and analysis by mass spectrophotometry with a plasma inductively connected in the semi-quantitative mode using a Perkin Elmer-Sciex ELAN 6000 equipment (AOAC, 1995). Phosphorus content was obtained by determination of orthophosphate by the method using ascorbic acid and a combined reagent (APHA, 1995). The results were expressed in milligrams of the corresponding mineral/100 g of sample.

The total energy value (TEV) was calculated using the traditional conversion factors for proteins (4 kcal/gram), lipids (9 kcal.gram^{-1}), and carbohydrates (4 kcal.gram^{-1}) according to FAO (2006). The results were expressed in kcal/100 g of fresh sample. Ascorbic acid was extracted using metaphosphoric / acetic acid as solvent and assayed by 2, 6-dichlorophenol indophenol calibrated using a standard vitamin C (Pongracz et al., 1971). The results were expressed in milligrams of ascorbic acid/100 g of fresh sample.
The polyphenols assay was performed following the spectrophotometric method using the Folin Ciocalteu (Cicco et al., 2009) in which gallic acid was adopted as standard polyphenol. The results were expressed in milligrams of gallic acid/100g of sample. Flavonoids determination was carried out after triple extraction with acetone / water / acetic acid (70/28/2: v / v / v) as solvent (Zhishen et al, 1999; Kim et al, 2003). The assay was performed in the presence of sodium nitrite $NaNO_2$ (5%) (w / v) and aluminum trichloride $A1C1_3$ (10%) (w / v). Quercetin was adopted as standard flavonoid.

Chemical analysis of fats

Total fatty acids composition was determined by gas chromatography (GC) (Chrompack CP9001 (FID) gas chromatograph, equipped with a CP - Sil 88 FAME fused silica WCOT 0.2 µm × 50 m × 0.25 mm capillary column (Chrompack catalog n.7488)) after cold extraction and transesterification of fatty acids. The operating conditions: temperature of the

Table 1. Proximate composition of "mustards".

Parameter	*Nere mustard*	Soy *mustard*
Moisture (g/100 g FW)	14.57±2.01[b]	25.97±3.93[a]
Proteins (g/100 g FW)	33.98±3.06[a]	32.38±3.52[a]
Lipids (g/100 g FW)	34.53±3.64[a]	20.12±1.76[b]
Carbohydrates (g/100 g FW)	13.87±3.27[b]	17.14±2.19[a]
Ash (g/100 g FW)	3.05±0.42[b]	4.39±0.81[a]
pH	7.22±0.37[a]	6.078±0.15[a]
Energy (kcal/100 g FW)	502.17±10.96[a]	373.24±22.93[b]
Iron (mg/100 g FW)	12.16±0.63[a]	8.38±0.3[b]
Zinc (mg/100 g FW)	7.87±0.45[a]	4.26±1.07[b]
Phosphorus (mg/100 g FW)	506.33±29.39[b]	582±9.58[a]
Calcium (mg/100 g FW)	316.7±70.89[a]	232.45±11.90[b]
Potassium (mg/100 g FW)	509.41±10.81[b]	1268.21±9.37[a]
Sodium (mg/100 g FW)	184.03±43.99[a]	74.71±5.96[b]

Means with the same superscript along the same line are not significantly different are 5% level.

injector = 250°C; temperature of the detector (FID) = 250°C; column initial temperature = 160°C (32 min), with rise of 3°C per minute until 200°C; column final temperature = 200°C (30 min); split of 1:100; carrier gas = hydrogen, at 70 KPa; and injected sample quantity = 0.2 µL. Each sample was injected only once (Huang et al., 2006). The software Alltech Allchrome More Chromatography Data System Version 1.4.2.1 (Alltech Association Inc., Lokeren, Belgium) was used to read the data. The peaks were identified by their retention times and by comparison with standard (Supelco 37 Component FAME Mix, Sigma-Aldrich, Bornem, Belgium). The results were expressed as the fatty acid composition in total lipid content.

Carotenoids determination

With regard to the analysis of carotenoids, the samples were submitted to lipid extraction and saponification steps. The determination of total carotenoids was carried out by high performance liquid chromatography (HPLC) operating under the following conditions: mobile phase: gradient of t-butyl methanol/methyl ether - 80:20 to 10:90 in 28 min; flow: 0.8 mL/min; detector: Photodiode Array (DAD) 300 500 nm; column: C30 3 µm× 250 mm - YMC Carotenoid waters; temperature of the column: 30°C; and injected sample volume: 0.2 µL, one injection for each sample (Rodriguez-Amaya, 2001). All analysis steps were conducted protected from light and the carotenoids was covered with aluminum foil. The extraction of total carotenoids followed by Hitachi-U 3200 spectrophotometer readings used a wave length of 449 nm (Rodriguez-Amaya and Kimura, 2001). The peaks identification was done by comparison with the carotenoids retention times from the standard used. The results were converted to wet basis and expressed in milligrams of total carotenoids/100 g of sample.

Statistical analysis

Results were expressed as mean ± standard deviation. One way ANOVA (SPSS 20.0 for windows, SPSS Inc. Chicago IL, USA) was used to analyse data. The difference between groups of each parameter was determined using the Duncan test and statistical significance was claimed at $P < 0.05$.

RESULTS

Chemical composition of "*mustards*", food condiments from fermented *P. biglobosa* seeds and *Glycine max* seeds are shown in Table 1. Except protein content (32.38±3.52 g/100 g of sample and 33.98±3.06 g/100 g sample), results showed that there were significant differences between these two varieties of *mustards*. According proximate composition, moisture and lipid are second greatest components. Total lipids ranged from 20.12±1.76 g/100 g in soy *mustard* to 34.53±3.64 g/100 g in African locust bean *mustard.* Nevertheless, moisture ranged from 14.57±2.01 g/100 g in African locust bean *mustard* to 25.97±3.93 g/100 g in soy *mustard*. However, energy content was significantly different and was higher in African locust bean *mustard* (502.17±10.96 kcal/100 g) than in soy *mustard* (373.24±22.9 kcal/100 g). Total carbohydrates, ash content and the pH in the two varieties of *mustards* were given almost in the same amounts.

Mustards content minerals (iron, zinc, calcium, phosphorus, sodium and potassium) were in considerable amounts. According to microminerals, iron and zinc are respectively higher in African locust bean *mustard* (12.16±0.63 g/100 g and 7.87±0.45 g/100 g) than in soy *mustard* (8.38±0.3 g/100 g and 4.26±1.07 g/100 g). Amongst the macrominerals presented in Table 1, potassium and phosphorus were found in highest concentration in the soy *mustard* (respectively 1268.21±9.37 g/100 g and 582±9.58 g/100 g) than in African locust bean *mustard* (respectively 509.41±10.81 g/100 g and 506.33±29.39 g/100 g).The oils of *mustards*

Table 2. Fatty acids composition of *mustards* (g/100 g of total fatty acids).

Fatty acid	Nere mustard	Soy mustard	Mustard*	Soy*	Palm*	maize*
Palmitic (C16:0)	10.5[b]	12.34[a]	0.5-4.5	8.0-13.5	8.0-14.0	8.6-16.5
Stéaric (C18:0)	16.94[a]	6.72[b]	0.5-2.0	2.0-5.4	1.0-4.5	-3.3
Oléic (C18:1c)	16.86[b]	24.64[a]	8.0-23.0	17-30	35.0-69	20.0-42.2
Linoléic (C18:2c)	34.41[b]	49.76[a]	10.0-24.0	48.0 -59.0	12.0-43.0	34.0-65.6
Linolénic (C18:3c)	0.24[b]	5.87[a]	6.0-18.	4.5-11.0	0.3	2.0
Arachidic (C20 :0)	4.45	-	1.5	0.1-0.6	1.0-2.0	0.3-1.0
Béhénic (C22 :0)	15.36	-	0.2-2.5	0.7	1.5-4.5	0.5
Saturated fatty acids	47.25[a]	19.06[b]	2.7-10.5	10,8-20.2	11.5-24.5	12.7-21.3
Unsaturated fatty acids	51.51[b]	80.27[a]	24-65	50.3-90	47.3-89.5	56-87.3
Mono-unsaturated fatty acids	16.86[b]	24.64[a]	8.0-23.0	17-30	35.0-69	20.0-42.2
Poly-unsaturated fatty acids	34.65[b]	55.63[a]	16-42	52.5-70	12.3-43.3	36-67.5
Non identified fatty acids	1.24	0.67	-	-	-	-

Means with the same superscript along the same line are not significantly different are5% level *CODEX STAN 210-1999.

Table 3. Antioxidant content present in “mustards” expressed in mg/100 g sample (Average ± s.d.).

Samples	Polyphenols (mg GAE/100 g FW)	Flavonoids (mg Equer/100 g FW)	Ascorbic acid (mg/100 g FW)	Total carotenoids (mg/100 gFW)
Nere mustard	100.01±24.29[b]	2.67±0.23[b]	19.31[a]	60.72±5.06[b]
Soy *mustard*	170.63±31.39[a]	5.28±1.92[a]	13.26[b]	100.86±8.45[a]

Means with the same superscript along the same column are not significantly different are5% level.

were characterized and have been compared to other oils usually used in Ivory Coast. Fatty acids were determined and results presented in Table 2, show significant difference between African locust bean *mustard* oil fatty acids and soy mustard oil fatty acids.

African locust bean *mustard* oil contains saturated acid in very large amounts than *soy mustard* oil. An average of 47.25 g/100 g of African locust bean *mustard* oil and 19.06 g/100 g of *soy mustard* oil was obtained. However, 1686 g/100 g of African locust bean *mustard* oil and 24.64 g/100 g of *soy mustard* oil, for mono-unsaturated, 34.65 g/100 g of African locust bean *mustard* oil and 55.63 g/100 g of *soy mustard* oil, for poly-unsaturated, were obtained. As for saturated acid, nere mustard and soy mustard showed the greatest values than mustard oil, soy oil, olive oil and palm oil. Mono-unsaturated acids in African locust bean *mustard* oil and *soy mustard* oil, were closer to values recommended in mustard oil and soy oil. And then, poly-unsaturated content in African locust bean *mustard* oil was closer to values recommended in mustard oil and palm oil. Poly-unsaturated content in *soy mustard* oil was closer to values recommended in soy oil and maize oil.

Regarding content of nutrients with high antioxidant activity, significant differences between the two varieties of mustard were presented, and very large amounts were found. Values of 100.01±24.29 mg/100 g of African locust bean *mustard* and 2.67±0.23 mg/100 g of African locust bean *mustard*, 170.63±31.39 mg/100 g of soy *mustard* and 5.28±1.92 mg/100 g of soy *mustard*, were found respectively for total polyphenols and flavonoids (Table 3). Average of 9.31 mg/100 g of African locust bean *mustard*, 60.72±5.06 mg/100 g of African locust bean *mustard* 13.26 mg/100 g of soy mustard and 100.86±8.45 mg/100 g of soy mustard, were found respectively for ascorbic acid and total carotenoids.

DISCUSSION

The moisture content in the centesimal composition of mustard deserves attention on account of being higher than 12. It was higher than values determined by Lamboni et al. (1999) which ranged from 6.35 to 9% for varieties of mustards (Mna and Mnas) manufactured in their laboratories. *Mustard* used in this study was probably not sufficiently stored after being manufactured, before them to the market.

Attention must be drawn to the high content of protein

found in this study, which was 33.98±3.06 g/100 g of African locust bean *mustard* and 32.38±3.52 g/100 g of soy *mustard*. Although African locust bean *mustard* and soy *mustard* can be considered as vegetable protein source, and the consumption of 100 g of *mustards* is capable of supplying significant amount of protein daily according to recommendation. The content of total carbohydrates in mustards was lower than the values (26.33 to 28.5) found in the study of Lamboni (1999). *Mustards* present some minerals in considerable amounts, which is extremely important since they act as co-factors in various metabolic reactions in the human organism. Amongst the macrominerals presented in Table 1, potassium was found in highest concentration in the pulp. This element is very important for its involvement in vital physiological functions, such as the osmotic and acid-base balances, and intra and extracellular concentrations related to the Na/K pump system (Mahan and Escott-Stump, 2002).

The third highest macromineral concentration in these mustards is attributed to calcium, relevant in the prevention of bone problems, such as osteoporosis in adults and rachitis in children, since low calcium consumption is a potential problem in Brazil (Vannucchi, 1990). Sodium as the lower component of the minerals content in these mustards, must be considered since it also operates in the osmotic and acid-base balances although it can cause health problems, such as hypertension, when ingested in high quantities (Shils, 2003**)**.

Microminerals (Table 1) were found in very large amounts. The highest concentration found in *mustards* was that of iron followed by zinc. Iron deficiency anemia has a high incidence in women and children in developing countries, which emphasizes the importance of the presence of this mineral in the pulp studied (Nogueira et al., 1998).

Zinc is essential because it is a co-factor for more than 100 enzymes, and participates in diverse metabolic processes such as cellular growth and multiplication, cicatrization, macrophage and lymphocyte functioning. The presence of these minerals in African locust bean *mustard* and *soy mustard* enriches the nutritional value and the true function in human metabolism, of this condiment even more.

If the bioavailability of these minerals is not considered, 100 g of African locust bean *mustard* and soy *mustard* can supply, comply fully with the daily requirements, both for men and women. Mineral elements are extremely related to human health and diseases since they can induce physiological changes in individuals (Gibson, 1989). From the public health point of view, it is important to assure the population that the ingestion of nere mustard and soy mustard is adequate to a normal diet. At the same time, the diet must not contain toxic elements above acceptable levels, preventing chemical poisoning.

The knowledge of the total energy value of foods is of great interest for the nutrition field since it makes it possible to know the calories ingested by the consumer. Therefore, the present study determined that the total energy value of 100 g of African locust bean nere *mustard* or soy *mustard* was higher to the value on the ENDEF Food Composition Table, which is 144.00 kcal (Instituto., 1999) (Table 1).

Result showed large amounts and significant difference in total lipids between African locust bean *mustard* and *soy mustard*. These mustards lipid must be valued for its oil and fatty acids, which are the main energy sources for the human body, and have been used by industries due to their abilities to dissolve flavor and aromatic compounds to modify various products consistency. The amount of fatty acids found in this study is similar to those found by Babacar et al. (2000) in *netetu* (a food condiment from fermented *Parkia biglobosa* seeds) of different origins available on the senegalian market. Regarding the amount of unsaturated fatty acids, they were found in very large amounts in these mustards.Nere mustard and soy mustard have the most interesting nutritional value because of their richness in unsaturated fatty acids (34.41 g/100 g of African locust bean *mustard* oil and 49.76 g/100 g of *soy mustard* oil of C 18:2 ω-6, and 0.24 g/100 g of African locust bean *mustard* oil and 5.87 g/100 g of *soy mustard* oil of C18: 3 ω-3). It is important to point out that the amount of oleic acid (16.86 g/100 g of African locust bean *mustard* oil and 24.64 g/100 g of *soy mustard* oil), were closer to values recommended in mustard oil and soy oil. Poly-unsaturated content in African locust bean *mustard* oil and in *soy mustard* oil were closer to values respectively recommended in mustard oil, palm oil, soy oil and maize oil, which are also widely used in the prevention of coronary heart disease.

Oleic acid contains a double bond on carbon 9, known as an omega-9 fatty acid and has a basic role in hormone synthesis in the human organism, and in the reduction of blood LDL cholesterol levels (Galvão, 2000; Turatti, 2000). Similarly, linoleic and linolenic fatty acids, compounds of the omega-6 (C18:2, ω-6) and omega-3 (C18:2, ω-3) families, respectively, also play important roles in the human organism since they are part of the cell membrane, and have antithrombotic and anti-inflammatory activities. They act as antithrombotic prostaglandin and leukotriene precursors and stimulate immunity, respectively, besides being related to the reduction of coronary heart disease and its risk factors (Chiarello et al., 2005).

Amongst the saturated fatty acids, palmitic acid (C16:0) corresponding to 10.5 g/100 g of African locust bean *mustard* oil and 12.34 g/100 g of *soy mustard* oil, which is in accordance with values determined by Lamboni et al., (1999) which is 12.4 g/100 g of total fatty acids, for

varieties of *mustards* (Mna and Mnas) manifactured in their laboratories, but it is one of the villains in blood cholesterol increase (Hartman, 1993).

African locust bean *mustard* and soy mustard oils, present higher values of both unsaturated fatty acids when compared to the oils which are also widely used in the prevention of coronary heart disease and its risk factors. However, it must be considered that these mustards used in foods submitted to heating do not have coronary heart disease risk factors. Therefore, this depending on the time and temperature of the process applied, undesirable alterations in the chemical structures of these fatty acids may occur, which will reduce their benefits to human health.

Regarding carotenoids, the results shown in Table 3 indicate that African locust bean *mustard* contains 60.72±5.06 mg total carotenoids/100 g, and soy mustard contains 100.86±8.45 mg total carotenoids/100 g. The fact that carotenoids exert many functions, for example, antioxidant activity represent vitamin A precursor, which makes this result of utmost importance for human life since African locust bean *mustard* and *soy mustard* could be used for the prevention of various diseases, amongst them eyesight problems caused by vitamin A deficiency, diseases that result from oxidative stress, such as cancer, amongst others (Luciana and Armando, 2011).

Ascorbic acid has various functions which are based mainly on its property as a reversible biological reducing agent.

Thus, it is essential as a co-factor for various biochemical reactions, and as a protective antioxidant that works in the aqueous phase, which can be regenerated in vivo when oxidized; it also affects a variety of factors associated to the risk of heart disease, including the integrity of vascular tissue, vascular tonus, lipid metabolism, and blood pressure (Horrobin, 1996). It can also increase non-heme iron absorption and participate in the formation of collagen. The results showed that the ascorbic acid contents in nere mustard (19.31 mg/100 g) and in soy mustard (13.26 mg/100 g) (Table 3) are much lower than those found in orange (50 to 100 mg/100 g orange) (Andrade et al., 2002).

Ascorbic acid and polyphenols also possess anti-atherosclerotic, anti-inflammatory, antitumor, antithrombotic, anti-osteoporosis and antiviral activities (Nijveldt, 2001). This research evidenced that 100 g of African locust bean *mustard* contained 100.01±24.29 mg of total polyphenols and 2.67±0.23 mg of flavonoids, also 100 g of soy mustard contained 170.63±31.39 mg of total polyphenols and 5.28±1.92 mg of flavonoids. These values are very higher than those found in the literature for carrot and Brussels sprouts (Cunha, 2005) (Table 3).

This characteristic is of great relevance to human health given its relationship with the prevention of diseases caused by oxidative stress, amongst others, as earlier mentioned.

Conclusion

In addition to its high nutritional status and its antioxidant properties conferred by its contents of polyphenols, ascorbic acid and carotenoids, African locust bean *mustard* and soy *mustard* contain bioactive compounds with functional activities due to the high concentrations of oleic acid and carotenoids, and for being a great source of vegetable protein. However, further studies are necessary to confirm the beneficial effects of those functional substances.

Conflict of Interests

The authors have not declared any conflict of interests.

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Full Length Research Paper

Evaluation of African giant snails (*Achatina* and *Archachatina*) obtained from markets (wild) and breeding farms

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In the Greater Accra Region there is high demand in consumption of molluscs, which indicates the need for studies on the possibility of disease transmission. Snail meat is usually susceptible to microbial contamination. Shelling is difficult with possibilities of cross contamination. Slime on the meat becomes a hurdle during commercial processing. The objective of the study was to establish the differences in the microbial load of African land snails (*Achatina achatina* and *Archachatina marginata*) from two sources (market and breeding farm) and to enumerate some consumer concerns about the snail meat. The results found that the total viable count (log_{10} CFU/g) ranged from 6.61±1.25 to 8.29±1.02. The total of coliform count (log_{10} CFU/g) ranged from 8.50±0.57 to 5.61±1.51. *Salmonella* count (log_{10} CFU/g) ranged from 2.91±3.19 to 7.39±0.45. *Staphylococcus*, *Bacillus* and *Pseudomonas* counts (log_{10} CFU/g) ranged from 7.68±1.40 to 2.66±2.99; 4.90±1.07 to 1.53±1.68 and 5.66±0.14 to 3.97±0.74, respectively. Most microorganisms identified were from the Enterobateriaceae family. Shelling, slime removal, contamination, price, packaging were problems associated with snail meat.

Key words: Molluscs, consumer behaviour, Enterobacteriaceae, contamination, food safety, Accra Metropolitan Area, Ghana.

INTRODUCTION

Apart from the conventional sources of protein; which are mainly meat and fish, snails (molluscs) are excellent sources of protein and mineral elements for many families. Snail meat is a nutritious food that is high in protein, low in fat and a good source of iron (USDA, 2006). According to Akinnusi (2002) snail meat is high in protein, iron, calcium and phosphorus, but low in sodium, fat and cholesterol, and contains almost all the amino acids needed by man. The meat is high in health benefiting essential fatty acids such as linoleic and linolenic acids. A study on a snail species in Brazil estimated that 75% of the fat in snail is unsaturated fatty

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acids. That is 57% polyunsaturated fatty acids, 15.5% of monounsaturated fatty acids and 23.25% of saturated fatty acids (Su et al., 2004), furthermore the African giant snails (*Archachatina marginata* and *Achatina achatina*) are considered as a delicacy in Nigeria and they command high demand in the market (Adeyeye, 1996).

The African giant land snail (*Archachatina marginata*) is the largest known snail in Africa (Olawoyin and Ogogo, 2006). Snails have high rate of productivity or fecundity. Though they are hermaphrodites, they practice sexual reproduction (Akinnusi, 2004). Snails are selective in their mating partners and sometimes uninterested in mating with other snails of the same species originating from a considerable distance away (Omole and Kehinde, 2005).

The natural habitat of snails are mostly found in the forest, farms and gardens where they have unlimited vegetation to feed on. According to Raut and Barker (2002), the most dominant types of vegetation in Africa are the tropical forest and the savannah where a wide variety of the African terrestrial Gastropods inhabit. Most land snails, especially, the African giant land snails that are eaten and exported are usually picked from their natural habitat. However, with the large market for the meat, many concerns have been raised about the reduction in their natural population. With challenges such as depletion of the stock of wild snails, over population, high cost of conventional animal protein, and also for health reasons, the demand for snails has increased such that commercial production is necessary. This led to the introduction of snail breeding farms with the purpose of supplying snails to meet the market demands.

The close contact of wild snails with soil and their uncontrolled feeding pattern make the snail susceptible to microbial contamination. Snails inherently have high populations of indigenous bacteria and coliforms and other poisonous substances which they ingest (ICMSF, 2005). The meat can be easily contaminated by pathogens and serve as vehicle of transferring infectious agents to consumers. Kirkan et al. (2006) reported the presence of *L. monocytogenes* in fresh snail sample which notably could have been contaminants from soil. So, despite rich nutritional values of snail, the involvement of the molluscs in the transmission of infection mostly as secondary host for pathogens makes it necessary to study the microbiology of the resident snail. The fact that consumption of field-collected snails may lead to bacterial infection, the provision of a systemic farming of snails will help solve both the problem of depletion of snail populations as well as provision of a relatively wholesome meat with less microbial contaminations (Upatham et al., 1988). This study therefore seeks to bring out the differences in the microbial quality of snails from two sources (wild and breeding farms) using two species of snails and to enumerate some consumer concerns pertaining the snail meat.

MATERIALS AND METHODS

Study area and snail species

The study area for the collection of samples was the Greater Accra Region. This is the capital town of Ghana, where there is high demand for meat. Samples were collected from five markets (Dome, Kaneshie, Madina, Makola and Mallam Atta) and five snail farms (Abokobi, Assin Fosu, Burma Camp, Madina and Nsawam) within the Accra Metropolitan Area and its surroundings. The *A. achatina* and *A. marginata* species were used for the study because they are the most preferred choice by the consumer. The *A. achatina* species are the most preferred and the most expensive amongst the two.

Survey on the preferences of snails

A study was conducted on consumer preferences of snails. Mixed questionnaires comprising both open ended and closed ended questions were administered to fifty consumers concerning the species and type of snails they preferred. Other questions were about the packaging, price, availability and the wholesomeness of the snails they buy. There were also questions relating to the problems associated with the preparation and cooking of the meat. A face-to-face interview technique was used in the administration of the questionnaires especially where the respondents could not read or write (Adeniyi et al., 2013).

Sampling procedure and microbiological analysis

Thirty matured live snail samples each in total of the two species were obtained from various markets in Accra. The samples were bought from market women who sold snails collected from the forest. Similarly, the same quantity of snails for each species, were obtained from breeding farms in Accra. Five snail samples each for both species were sampled from the total quantity and used for the study. The experiment was replicated three times. The snail samples were collected in a sterile bag and labelled according to its source. The samples were scrubbed, rinsed with water to remove surface dirt. They were then washed with sterile distilled water and scrubbed with ethanol to remove external microorganism, the meat was aseptically extracted and homogenized. Sample preparation was done under sterile conditions in the laboratory under the laminar flow cabinet. A 10 g of sample (snail) was immediately transferred into 90 ml peptone water for analysis. Standard pour plates were prepared from 10-fold dilutions into nutrient agar medium for total bacteria counts, Violet red bile agar for total coliform counts, Xylose Lactose Desoxycholate (XLD) agar for total *Salmonella*/*Shigella* counts, Baird-Parker agar enriched with egg - yolk emulsion for *Staphyloccocus* count, *Bacillus cereus* select agar for *Bacillus* count and *Pseudomonas* agar for total *Pseudomonas* count.

The bacterial plates were incubated at 37°C for 24 to 48 h. Colonies were selected randomly and were characterized using morphological and biochemical tests such as gram stain, spore stain, motility, catalase, oxidize, coagulase, indole, MR-VP, urease and sugar fermentation tests. Bacterial isolates were identified with reference to Cowan and Steel's Manual for the Identification of Medical Bacteria (Cowan, 1985) and Bergey's Manual of Determinative Bacteriology (Holt et al., 1994). Identification for this and other microorganisms were further done using the API 20E (BioMerieux, Boston, USA).

Data analysis

The means of each result was calculated for each source from

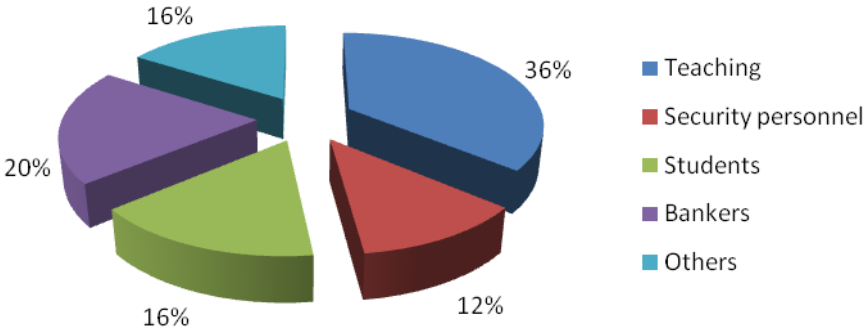

Figure 1. Occupation of respondents.

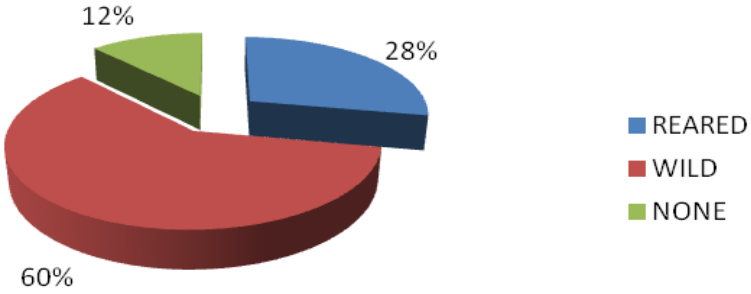

Figure 2. Preference for wild or reared snails.

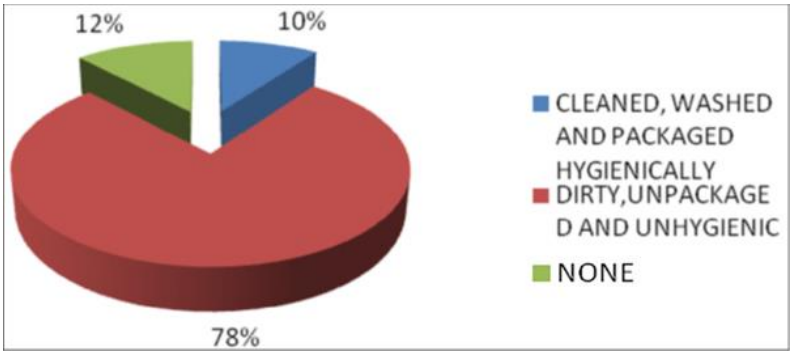

Figure 3. Presentation of fresh snails for sale.

triplicate plate counts and from the repeated survey. The means obtained from each source was separated using *t*- test. Data obtained from samples were analyzed using Microsoft Excel and Statgraphics Centurion XVI (Stat-point Technologies, Inc., Warrenton, Virginia, USA). Means were separated using Duncan's multiple range test.

RESULTS

Problems associated with the sale and consumption of the snail meat

Respondents used for the study had different occupational background ranging from teaching, security, banking, among others (Figure 1).

There was high preference for wild snails than the reared ones. Respondents admitted buying snails which are unpackaged and in an unhygienic state, some of the respondents agreed to a possible contamination of the snail meat presented for sale on the market. Most of the respondents indicated their preference for processed and packaged fresh snails. Consumers enumerated various problems associated with preparation of snails, ranging from the slime, shelling and dirt (Figures 2 to 7).

Mean count of microorganisms of snails from two sources (breeding farms and wild)

The microbial load of snail from both sources is shown in

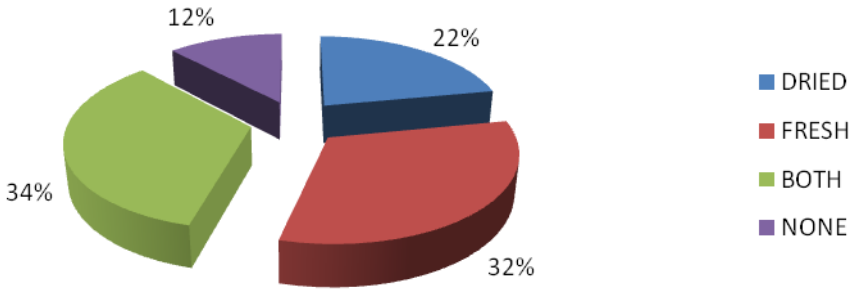

Figure 4. Type of snails preferred.

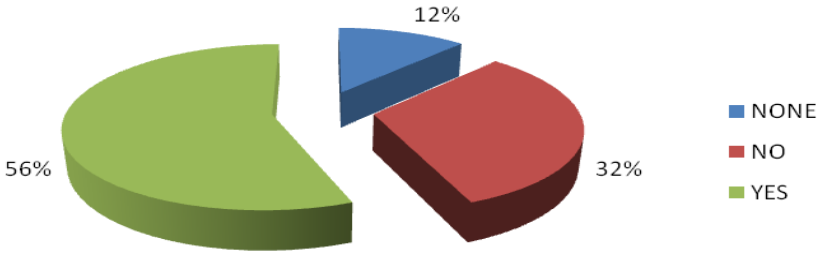

Figure 5. Possibility of contamination.

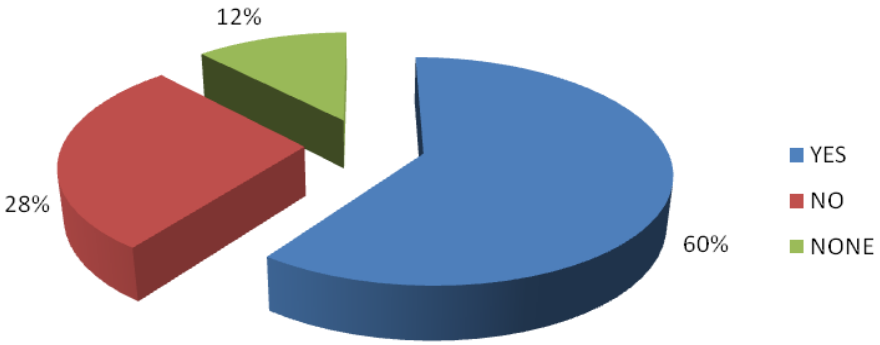

Figure 6. Preference for processed and packaged snails.

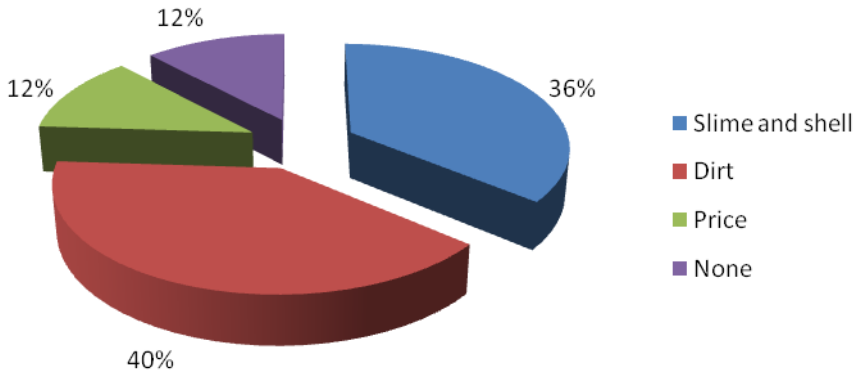

Figure 7. Problems associated with purchasing, preparation and cooking of snails.

Table 1. Total microbial count (log_{10} CFU/g) in fresh land snail samples from different farms and markets.

Market of snail samples	Sample code	Total bacterial count	Total Coliform count	Total *Salmonellal Shigella* count	Total *Staphylococci* count	Total *Pseudomonas* count	Total *Bacillus* count
Makola	MK	6.79±0.97^{A}	6.32±0.05^{A}	5.13±0.47^{A}	5.69±0.22^{A}	5.24±0.36^{A}	4.18±0.417
Madina	MD	7.13±0.40^{A}	7.07±0.61^{AB}	5.47±0.43^{A}	6.18±1.81^{A}	4.80±0.32^{A}	4.17±0.09
Kaneshie	KN	7.86±0.72^{B}	8.26±0.56^{C}	6.86±0.49^{B}	7.68±1.40^{A}	4.64±0.11^{A}	4.69±0.09
Dome	DM	8.04±0.48^{B}	7.17±093^{B}	6.40±0.43^{BC}	5.85±0.10^{A}	5.17±0.33^{B}	4.77±1.07
Mallam Atta	MA	8.19±0.30^{B}	8.50±0.57^{C}	7.39±0.45^{C}	5.91±0.05^{B}	4.86±0.08^{B}	4.90±1.07
Average		**7.60±0.79**	**7.46±1.02^{B}**	**6.25±0.95^{B}**	**6.26±1.21^{B}**	**4.94±0.31^{B}**	**4.65±0.72^{B}**
Breeding farms							
Abokobi	AB	6.61±1.25^{A}	6.71±1.9^{A}	2.91±3.19^{A}	3.39±3.72	5.39±0.39^{A}	2.78±0.56
Madina	MD	6.84±0.83^{A}	5.61±1.51^{AB}	3.30±0.50^{A}	3.90±2.46	4.74±0.13^{B}	1.53±1.68
Assin Fosu	AF	7.54±0.01^{AB}	7.17±0.33^{AB}	5.51±0.17^{A}	3.26±3.57	6.13±0.34^{C}	3.32±3.48
Nsawam	NS	7.12±1.47^{AB}	7.38±1.75^{C}	3.38±3.70^{AB}	2.80±3.07	5.66±0.14^{CD}	3.76±0.01
Burma camp	BC	8.29±1.2^{C}	6.92±0.02^{C}	6.79±1.21^{B}	2.66±2.99	3.97±0.74^{D}	2.37±2.60
Average		**7.28±1.14**	**6.76^{+}±1.25^{A}**	**4.38±2.60^{A}**	**3.20±2.99^{A}**	**5.17±0.86^{A}**	**2.75±2.16^{A}**

Markets, MK- Makola, MD- Madina; KN, Kaneshie; DM, Dome; ML, Mallam Atta; Farms AB- Abokobi; MD, Madina; AS, Assin Fosu; NW, Nsawam; BC, Burma Camp. Different uppercase subscripts within the same columns are significantly different (P≤0.05).

Table 2. Pooled mean count of microorganisms from two species of snails.

Species	Total bacterial count	Total coliform count	Total *Salmonella* count	Total *Staphylococcus* count	Total *Pseudomonas* count	Total *Bacillus* count
	Log_{10} CFU g^{-1}					
A.A	7.87±1.07^{B}	7.47±1.28^{B}	4.38±2.61^{B}	4.96±2.77	5.24±0.57^{B}	2.90±2.13^{B}
A.M	7.01±0.66^{A}	6.75±0.79^{A}	5.98±1.32^{A}	4.51±2.72	4.87±0.68^{A}	4.51±1.08^{A}

Values are mean count ± standard deviation. *Different uppercase subscripts within the same columns are significantly different (P≤0.05). A.A, *Achatina achatina*; AM, *Archachatina marginata*.

Table 1. The total viable count (log_{10} CFU/g) ranged from 6.61 to 8.29. The highest count was observed at samples from Burma Camp. The total coliform count (log_{10} CFU/g) ranged from 5.61 to 8.50; samples from Mallam Atta market had the highest count. *Salmonella* count (log_{10} CFU/g) also ranged from 2.91 to 7.39 with Mallam Atta recording the highest count. The total Staphylococcal count (log_{10} CFU/g) also ranged from 2.66 and 7.68 with Kaneshie recording the highest count. *Pseudomonas* and *Bacillus* count (log_{10} CFU/g) ranged from 6.13 to 3.97 and 1.53 to 4.90 and the highest counts were seen at Nsawam and Mallam Atta, respectively (Table 1).

There were no significant differences (P≥0.05) in the total mean obtained for the total viable count, from both sources (Table 1). However, there were significant differences (P ≤0.05) in the total mean counts obtained for coliform, and a highly significant differences (P ≤0.001) in the total mean counts for *Salmonella*. A highly significant differences (P ≤0.000) in total mean counts for both sources were recorded for *Staphylococcus*, and similarly, for *Pseudomonas* and *Bacillus* (Table 1).

Mean count of microorganisms from two species of snails

The microbial load of two species of snail samples is shown in Table 2. *A. achatina* samples had the highest count for total viable count, coliform, *Staphylococcus* and *Pseudomonas* and a lower count for *Salmonella* and *Bacillus cereus.*

Microorganisms identified from the breeding farms and the wild samples using API and some Biochemical Tests (BT)

Most of the microorganisms isolated from the wild samples were enteric bacteria (Table 3).

DISCUSSION

Problems associated with purchasing and consumption of snail meat

Even though snail meat is known to be highly nutritious,

Table 3. Phenotypical characterization of the most representative microorganisms isolated from fresh land snail samples from different breeding farms and markets.

Isolates	Snail samples									
	Market						Breeding farms			
	MK	MD	KN	DM	ML	AB	MD	AS	NW	BC
Citrobacter freundii	+	+	-	+	-	-	+	+	+	+
E. coli spp	+	+	+	-	+	-	-	-	+	-
Enterobacter aerogenes	-	-	+	-	-	-	-	-	+	-
Enterobacter clocae	-	-	-	-	+	+	+	+	-	-
Klebsiella pneumonia	-	-	-	+	-	-	+	-	+	-
Micrococcus spp.	+	+	-	+	-	-	-	-	-	-
Proteus spp.	-	+	+	+	+	-	-	+	+	+
Salmonella spp.	+	+	+	-	+	-	+	-	+	-

MK, Makola; MD, Madina; KN, Kaneshie; DM, Dome; ML, Mallam Atta; AB, Abokobi; MD, Madina; AS, Assin Fosu; NW, Nsawam; BC, Burma Camp.

several problems associated with the snails prevent a number of people from patronising it, especially, consumers who engaged in sedentary work with little time at their disposal.

The percentage of individuals who do not eat snails may be due to traditional, religious and cultural believes associated with the meat, health problems such as allergies among others (Ebenso, 2003). According to Ogbuagu and Okapara (2011), eating of snail is forbidden in some local communities and amongst some individuals due to cultural/religious beliefs or because of the feeding habit of snails. This is contrary to some beliefs that the meat has traditionally been a major ingredient in the diet of people living in high forest zone and the rural communities (Agbogidi and Okonta, 2011). Recently, snails are now consumed by a large number of people in the urban areas. This upsurge resulted from studies on their nutritive value which showed the 'foot' (the part eaten by people) to be rich in essential fatty acids such as linoleic and linolenic acids, required for normal tissue development and maintenance (Malik et al., 2011).

There are basically two types of snails on the Ghanaian market. There are the fresh snails, sold with the shell and the smoked- dried snails, shelled and skewed on a stick. Of these two types, the most preferred is the fresh snails. Respondents preferred the fresh snails because they claimed the fresh ones are more nutritious (Figure 4). A part from the high preference for fresh snails, traditionally preserved foods like smoked dried bush meat (game), stink fish are relished by Ghanaians for their peculiar taste and aroma. For this reason, there is high preference for the smoked- dried snails as well. Smoke drying the snails not only provides a different type of snails on the market but leads to the preservation of the snails against the lean seasons.

Snails that are usually sold on the market are hand-picked from the forest or their natural habitat where they live naturally and are considered as wild. These ones constitute a large percentage of those sold on the market. They are also the preferred choice by consumers (Figure 5). The high preference for the wild snails comes from the belief that these have a better taste; however, their availability on the market is threatened in the near future. High demand of the wild snails had led to massive collection of the meat from the forest and the wild, depleting their population and possibly resulting in extinction of some of the species. Hence the few remaining species are captured before they reach maturity. The need to promote the domestication and rearing of these animals therefore cannot be overestimated.

Production and the sale of snails has remained a traditional and indigenous work. Right after they have been collected from the forest or from the farm, they are usually sold in the same state in which they were collected, that is, together with their shell. This product is yet to be processed into an attractive and a more hygienic form. The sale of both fresh and smoked dried snails in Ghana has been an indigenous work mostly preserved for market women who engaged in its trade. There has been no regulation concerning how the meat should be sold or presented to consumers. Traditionally smoked dried snail meat is not packaged but displayed on open trays for sale and at the end of the day; the unsold ones are packed into wooden boxes or sacks introducing various sources of contamination through human handling and other environmental factors (Tettey et al., 1997).

Due to the natural habitat of snails and their feeding habits, there is a high possibility of the meat being contaminated with lots of microorganisms. Snails are usually picked from the soil were they live, feed and breed, however, the soil is a host of several microorganisms most of which are pathogenic. There are growing interests to the extent to which edible land snails may present a threat to the health of humans (Ekundayo and Fagade, 2005). Efuntoye et al. (2011) isolated approximately two species of *Staphylococcus* in the

intestines of different types of snails, with *S. aureus* being isolated from 27 individual *A. marginata* and 7 from *A. achatina*. Lack of accessible information and ignorance of the consumers may account for their perception of no contamination for the snails.

There was high preference for processed, packaged snails. Respondents explained the preparation of snail is difficult, time consuming and require additional resources to get them ready for use. A processed and well packaged fresh snail not only becomes handy for use but reduces its preparation time and is much more hygienic.

In the era of global change and massive technological advancements, efforts are targeted at improving the quality and adding value to existing products. Changes in family lifestyle, and increased ownership of freezers and microwave ovens, are reflected in demands for foods that are convenient to prepare, are suitable for frozen or chilled storage, or have a moderate shelf life at ambient temperatures (Fellows, 2000). The acceptance of these newly improved products on the other hand, usually prevents the possibility of developing them.

Respondents reported slime and shelling of snails, dirt, and price of the snails as some problems associated with the meat (Figure 7), however, there is an inverse relationship between the high cost (price) of snails and its consumption rate due to the high demand for snails. Unlike meat or fish, snail preparation could be very complex. In addition to the fact that snails need to be shelled, which required some skills in doing so, there are also problems associated the slime found on them. One complication in commercial processing of snail meat has been the mucus or "slime" secreted by the snails, used in their locomotion, defence, water retention and other physiological activities (Gallo, 2002). Snails are also dirty and covered with mud since they are mostly on the ground. All these, prevents consumers from patronising it. Consumption of snail meat is continuously increasing because many consumers eat snails for various reasons (Ogogo et al., 2011). While some consumers patronise the meat for health reasons, others harness its believed medicinal values. The low content of fat (1.3%) and low cholesterol level makes snail meat a good antidote for vascular diseases such as heart attack, cardiac arrest, hypertension, stroke, high blood pressure and other fat related ailments (Akinnusi, 2002). Medicinally, Ayodele and Ashimolowo (1999) reported that, among the people of West Africa specifically, the Yoruba speaking people of the South Western Nigeria, snail is a requirement in several preparations in traditional medicine. At the household level, nursing mothers depend on the snail mucus for treating wounds from the umbilical cords. All these medicinal attributes are however yet to be proven.

Microbiological quality of snails from two sources

The TVC ($\log_{10}$ CFU/g) from the microbial survey ranged from 6.61 to 8.29, however, higher values of 10.41 of *A. achatina* were obtained before purging (Antwi, 2009) and 8.16, 8 and 8.17 for *Achatina fulica*, *Limicolaria* and *Helix pomatia* species of land snails (Adegoke et al., 2010). The value was close to 6.85 for *Helix aspersa,* a land snail popular to the European (Temelli et al., 2006). The TVC from the different markets and farms were also higher than the recommended levels acceptable of 5×10^5 CFU/g for shell fish and fishery product (ICMSF, 1980). According to ICMSF (2005), snails may contain some parasites and other pathogenic bacteria which cannot be gotten rid of even after purging. This is due to the swamps and marshes in which they are found. A study conducted on the microbial load of snail farm soil reported a count of 5.35 to 5.85 ($\log_{10}$ CFU/g) of different snail farms in Nigeria (Ekundayo and Fagade, 2005). The same study revealed a count ($\log_{10}$ CFU/g) of 5.43 and 5.08 in the visceral mass of snails obtained from different snail farms. This indicates some relationship between the microbial load of snail and the soils they have contact with. The visceral fluid and excretion process of the snail can result in cross contamination of the meat. Efuntoye et al. (2011) isolated several species of *Staphylococcus* from the intestines of snails of both *Achatina* and *Archachatina* species. Total viable count is used to indicate the level of microbial contamination of a product (Maturin and Peeler, 1998). Although this may not directly relate to food safety hazard, it can be used to indicate the quality, shelf life and post- harvest contamination of these foods.

The total coliform count ($\log_{10}$ CFU/g) from both sources were however higher than 2.77 (Temelli et al., 2006) for *H. aspersa* and 5.25 for aquatic snails (periwinkles) (Adebayo-Tayo et al., 2006). Similar findings were made by Adegoke et al. (2010) with counts ($\log_{10}$) of 7.30, 7.22 and 7.34 for *A. fulica*, *Limicolaria* spp. and *H. pomatia*. High levels of coliform indicate feacal contamination of the natural habitat of these snails. This could be due to negative human activities carried out in the wild (forest) where these snails are particularly picked from and sold in the market. In addition, organic manure applied on farms where these snails are picked can also increase the coliform counts and other microbial counts of snails obtained from such areas. According to Adagbada et al. (2011), there is a close association between snails and microorganisms because their habitat is made up of filth, sewage, manure, rotten materials and poor latrine system which increase the microbial load of land snails.

High coliform counts from snails of the breeding farm samples could result from contaminated water and feed used since there are no regulations governing rearing of snails. The practice of domesticating and rearing snails has now been taken over by individual farmers with some assistance and training from the Ministry of Food and Agriculture, Ghana. This assistance however does not include regulating the quality of feed and water, or the

general sanitary conditions practiced. Another possible source of contamination among the breeding farm samples is the presence of other decomposed snails or their feacal material which had become part of the soil. Ekundayo and Fagade (2005) reiterated the fact that, high coliform, bacteria counts and pathogenic organisms associated with reared snails are due to the feacal materials and dead snails which decompose in the farm soil. Their findings also indicated that, as a result of snails licking the slime of infected snails or dead rotten snail, the microbial flora of the meat could be high.

Regarding *Salmonella*, similar counts ($\log_{10}$) of 7.77, 7.96 and 7.71 were reported for three different species of land snails (Adegoke et al., 2010). Adebayo-Tayo et al. (2006) also enumerated *Salmonella* count of 6.04 $\log_{10}$ from acquatic snail (periwinkles) which were also within similar range, however, lower count ($\log_{10}$) of 4.30 and 5.65 were reported for aquatic snail and oysters, respectively (Adebayo-Tayo et al., 2008). The level of shell fish contamination is directly dependent on the level of pollution in their habitat (Ekanem and Adegoke, 1995). According to Huss et al. (2000), *Salmonella* species are reported to form a natural micro flora in farms and pools of shell fish where they are raised and their presence in all snail samples indicates their contact with feacal matter originating from humans, animals or the snails themselves. Since *Salmonella* causes food poisoning in human, their presence in food should be totally eliminated. Efficient processing methods should be done to eliminate the organism totally from the cooked snail meat (Parlapani et al., 2014).

Similarly, *Staphylococcus* counts of 3.96 $\log_{10}$ was reported for life snails before boiling by Temelli et al. (2006). In another study conducted on the microflora of snail farm soil, an average range ($\log_{10}$) of 3.17 and 3.41 was obtained for Staphylococcal count (Ekundayo and Fagade, 2005).

There are various strains of *Staphylococcus*, but the most important strain responsible for food intoxication and of public interest is *S. aureus*. This bacterium is heat sensitive and can be eliminated by cooking; however, its toxins are relatively heat stable and may continue to remain in food after cooking. According to Brooks et al. (2004), *S. aureus* may be easily killed by boiling but they produce enterotoxin that is stable to heat at 100°C for 30 min and this toxin is known to cause food poisoning.

Adagbada et al. (2011) revealed a 4.4% of *Pseudomonas* species isolated from different species of snails. One major source of *Pseudomonas* is the soil therefore; *Pseudomonas* is a likely microflora of the meat due to their close association with the soil. According to Bibek (2005), many types of moulds, yeast and bacterial genera such as *Pseudomonas* can enter food through the soil or through animals that are reared on the soil. According to a research conducted by Ekundayo and Fagade (2005), *Pseudomonas* was isolated from the snail farm soil (3.32 $\log_{10}$) and from the visceral mass of the snail (2.50 $\log_{10}$). *Pseudomonas* spp. can be found in a lot of food commodities such as meat and fish including shellfish both of aquatic and terrestrial origin. They are mostly associated with food spoilage even at lower temperatures such as refrigeration temperatures. Yagoub (2009) isolated 62% of *Pseudomonas* spp. from 150 collected samples of shellfish. This is of much concern because *Pseudomonas* is an important indicator of quality control in food processing.

Bacillus species are widely distributed in the environment and can be found in the soil, dust, plants and on animals. Most *Bacillus* species have been isolated from different species of snails. Adagbada et al. (2011) *Bacillus cereus* is a spore forming bacteria associated with many foodborne illnesses. They can be present in undercooked meals since their spores are heat resistant. The bacteria are able to produce more cells under favourable conditions (Wang et al., 2010), therefore, this organism becomes an important concern especially in situations where snails are grilled for the preparation of khebab without adequate cooking to eliminate the spores. The differences in the microbial load of the two species might have resulted from the peculiar habitat of the species. According to Hodasi (1984), the Central and West African species of *Achatina* are confined to humid areas whilst the *Archachatina* species are distributed in less humid areas. This may contribute to the difference in the microbial load observed.

Some microorganisms identified from the snail samples

The results reinforce the importance of the analyses regarding the presence of enteric bacteria. Brenner (1984) described enteric bacteria as facultative aerobic gram negative non spore formers from the family of Enterobacteriacecae. Their presence in food usually indicates feacal contamination or insanitary conditions. Most of these organisms are pathogenic while others produce toxins responsible for intoxication.

Salmonella spp. which was identified in the samples, were also isolated from snails sampled from different markets in Nigeria (Adagbada et al., 2011).

E. coli was mostly isolated from the market samples because these were much exposed to feacal contamination. In another study conducted by Adebayo-Tayo et al. (2011), *E. coli* was isolated from *A. achatina* and other aquatic snails. Periwinkles and oysters also had *E. coli* isolates identified in them (Adebayo-Tayo and Ogunjobi, 2008). Evans and Evans (1995) classified *E. coli* as gram negative bacilli of the family Enterobacteriaceae and normal flora of the large intestines. According to them, strains that acquire bacteriophage or plasmid DNA encoding enterotoxins usually become virulent causing major health problems. It

is to be noted that *E*. *coli* infections in human results from oral ingestion of food contaminated with the pathogenic strains shed by the infected persons.

Citrobacter freundii, *Klebsiella pneumonia* and *Proteus* spp. are microorganisms responsible for many nosocomial infections in man. While *Proteus* spp. and *Klebsiella* are commonly responsible for urinary tract infection, *Klebsiella pneumonia* causes severe pneumonia in humans. *Citrobacter freundii* and other *Citrobacter* spp. are also known to cause urinary and respiratory tract infections, meningitis, septicemia and pulmonary infections in neonates and young children (Barons, 1996).

Other research by Adagbada et al. (2011) identified *Enterobacter* spp. in different species of snails. Different species of *Micrococcus* were also isolated from acquatic snails and *A*. *achatina*. Even though these organisms were not of much public concern, recently, they have been involved in a number of health problems. *Enterobacter* spp. is known to be responsible for urinary tract infections and can cause lethal effects in immuno-compromised patients.

Conclusions

Consumers had enumerated many problems associated with fresh snails. Some of these problems were difficulty in shelling, the presence of the mucus or slime found on the meat and its interference during meal preparation, possibility of contamination of the meat, packaging and the price of the snails. Shelling of the meat by sellers may cause cross contamination of the meat. Shelling the snail can be time consuming and injurious to consumers. The slime or mucus found on the meat interfered with preparation and gave some consumers 'cold feet'. All these problems render the meat unattractive for consumers. The two species of snails obtained from the market (wild) and the breeding farms had high counts of microorganisms. Samples obtained from the market sources however had higher counts. Most microorganisms isolated from the snails were from the Enterobacteriaceae family. Some of the isolates include *Salmonella*, *Escherichia coli*, *Klebsiella pneumonia*, *Enterobacter clocae*, *Micrococcus* spp. and *Proteus* spp. whilst some of these microorganisms are pathogenic, others are spoilage microorganisms. Some of these microorganisms were opportunistic organisms responsible for a host of human nosocomial infections.

Conflict of Interests

The authors have not declared any conflict of interest.

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QUESTIONNAIRE FOR CONSUMERS

This survey is part of an ongoing scientific study carried out to research into various processes, methods and storage conditions of snails before packaging and distribution. It is therefore to be treated as highly confidential as possible. You must tick where appropriate. Thank you for your co-operation.

DATE……..

A. PERSONAL DATA OF THE RESPONDENT

SEX: M ☐ F ☐

AGE:

Occupation ……..

Level of education Primary Secondary Tertiary

Language spoken Ewe ☐ Twi ☐ Ga ☐ Others ☐

B. QUESTIONS RELATING TO PRODUCT

1. Do you eat snails? Yes ☐ No ☐

2. If Yes, which type do you prefer? Dried ☐ Fresh ☐ Both ☐

3. Give reasons for your answer.

……
……

4. Which type of snails do you buy? Reared wild

5. How is the snail presented for sale?

a. Clean, washed and packaged under hygienic conditions

b. Usually dirty, unpackaged and unhygienic

6. How much do you buy the snails?

Quantity…… Price, ……₵

7. Do you think the snails sold in the market may be contaminated?

Yes ☐ No ☐

8. How would you prefer them being sold?

……
……

9. Would you prefer processed and packaged fresh snails without shells?

Yes ☐ No ☐

10. If Yes, why?

……
……

11. Will you prefer processed and packaged dried snails? Why?

……
……
……..

12. Are snails available for purchase all year round? Yes ☐ No ☐

13. If No, indicate which month/months they are in season.

……
……
……

14. Why do you eat snails?

……
……
……..

15. What do you dislike about the purchasing, preparation and cooking of snails bought from the market?

……
……
……..

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Full Length Research Paper

Sensory evaluation of extruded quality protein maize-based supplementary foods

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Maize porridge is widely consumed by children less than five years of age in Tanzania and other countries. The aim of this study was to evaluate the sensory attributes and the overall acceptability of the extruded quality protein maize-based supplementary foods for children in Tanzania. Two ready-to-use supplementary foods were produced by extrusion cooking (quality protein maize-soybeans-common beans and quality protein maize-soybeans-cowpeas) using the following food ingredients: quality protein maize, soybeans, common beans and cowpeas. Sugar, vitamins and mineral premix were added. These products were tested against a control diet made from common maize, soybeans, millet, wheat and groundnuts. A panel of sixty consumers was involved in the evaluation of sensory attributes of the porridge samples and overall acceptability was determined using 5 point Hedonic scale. Descriptive analysis was performed by 11 trained panelists using the lexicon developed. Statistical analysis was performed using analysis of variance and principal component analysis. Consumer evaluation revealed that quality protein maize-soybeans-common beans porridge was rated higher ($p<0.05$) for aroma (4.6) and taste (4.6) than all porridge samples tested. Despite higher rating in aroma and taste, all the porridges (quality protein maize-soybeans-common beans, quality protein maize-soybeans-cowpeas and conventional porridge) were equally acceptable ($p>0.05$) by the test panelists. Mean scores for overall acceptability of quality protein maize-soybeans-common beans, quality protein maize-soybeans-cowpeas and conventional porridge were 4.6, 4.3 and 4.2, respectively. All the three porridges were differentiated ($p<0.05$) using the identified language for quantitative descriptive study. The sensory attributes of colour, oiliness, aroma, sweetness, liking and aftertaste in principal component 1 distinguished experimental porridges from the control. However, all the food products could be described by viscosity, sweetness and colour in principal component 2. This was an indication that test diets, quality protein maize-soybeans-common beans and quality protein maize-soybeans-cowpeas resembled the control diet by some attributes namely, aroma, aftertaste and sweetness and therefore, had higher potential for acceptance by consumers.

Key words: Supplementary food, sensory attributes, consumer preferences, principal component analysis, Tanzania.

INTRODUCTION

Child under-nutrition is often widespread where staple foods are mostly plant-based and consumption of animal-based foods is limited due to high prices that many people cannot afford. Throughout the developing world,

34% of the children under the age of five years are stunted, 25% are underweight while 10% are wasted (Fanzo, 2012). In Tanzania, 42% of children under the age of five years are stunted, 16% are underweight while 5% are wasted (NBS [Tanzania] and ICF Macro, 2011). These nutritional deficiencies have been linked to several causes, such as inappropriate feeding practices, high prevalence of infections and intake of foods that are low in nutrient quantity and quality. In Tanzania, the most common foods introduced to young children are made from maize, more often nothing is added to it to improve the protein and/or micronutrient contents. Intake of plain maize porridge has been associated with under-nutrition for children under the age of five years (Desalegn et al., 2015). Maize is low in amino acids lysine, tryptophan and micronutrients which are needed for optimal child growth and some of these are lost during processing of flour.

Various approaches have been devised in addressing the problem of under-nutrition globally. One of them was by International Maize and Wheat Improvement Center (CIMMYT) that involved developing maize cultivars (biofortification) with protein high in lysine and tryptophan called quality protein maize (QPM) (CIMMYT, 2003). QPM has chemical composition similar to the normal maize (CM) except that it contains higher levels of amino acids lysine and tryptophan (Boateng et al., 2012; Kiria et al., 2010). In spite of maize being predominantly consumed in Tanzania and that QPM has been adopted since 2001, there has been only few acceptability studies done on QPM. Some of these involved the use of QPM on making stiff porridge and snacks. However, there is limited information on the use of QPM in making supplementary foods for children. Therefore, this study focused on evaluating the sensory quality and acceptability of QPM-based supplementary foods for children.

MATERIALS AND METHODS

Quality protein maize (LISHE K-1) that was used for the study was purchased from Seliani Research Station, Arusha. Common maize (*Zea mays*), soybeans (*Glycine max*), common beans (*Phaseolus vulgaris*), cowpeas *(Vigna unguiculata*), vegetable oil and sugar were purchased from Morogoro Municipal central market. Micronutrient powder (MNP) used to fortify the diets was purchased from Tuboreshe Chakula Project, Dar es Salaam.

Research design

This was an experimental study in which a complete randomized design (CRD) was employed. The study was done at two levels, which were consumer liking/disliking and quantitative descriptive studies with the principal factor being the diet.

Table 1. Composition of the QPM-based supplementary food formulations and the control.

Ingredients	Formulation (g)		
	QSB	QSC	CP
QPM	52	54	-
Soybean	8	6	14
Common maize	-	-	57
Cowpeas	-	34	-
Millet	-	-	19
Wheat	-	-	5
Common beans	34	-	-
Ground nut	-	-	5
Micronutrient powder	1	1	-
Sugar	5	5	-
Total	100	100	100

QSB = quality protein maize-soybean-common beans: QSC= quality protein maize-soybean-cowpeas: CP= Common maize-based flour.

Product processing and formulation

Separately, QPM, soybeans, common beans and cowpeas were cleaned by winnowing, removal of pebbles and chaff and washed in distilled water. QPM and soybeans were thereafter dehulled, cleaned and dried under the sun until a moisture content of 10% was attained. All ingredients were milled to fine flour (mesh size 0.4 mm).

After extrusion, two products namely QPM-soybeans-common beans (QSB) and QPM-soybeans-cowpeas (QSC) were formulated as indicated in Table 1. The formulations were designed to meet the highest amino acid score and the desired amount of energy and fat according to the FAO/WHO/UNU (1985) Codex Alimentarius guidelines for supplementary foods for infants and young children. Lipid contents of the products were adjusted to 10% using vegetable oil. The control diet made from plain maize flour and commonly known as nutritious flour ‘unga lishe’ was purchased from Mansooma supermarket in Morogoro.

Extrusion of foods

Before extrusion, moisture content of the maize-legume blends was adjusted to 21%. Extrusion of the composite flours was carried out in a commercial twin-screw extruder (Model JS 60 D, Qitong Chemical Industry Equipment Co. Ltd, Yantai, China). The following extrusion conditions were adopted: Temperatures 130 to 139°C (Zone 1) and 100 to 122°C (Zone 2) and a retention time of 2 min. Main motor speed was set at 10.48 rpm and feeder speed at 10.26 rpm. After extrusion, the extrudates were allowed to dry at room temperature overnight. Thereafter, the extrudates were milled and packaged in moisture proof polyethylene.

Porridge preparation

Two porridge samples were prepared from the extruded, fortified

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flour of QSB and QSC. The third porridge sample , not extruded and unfortified 'the control' was made from conventional maize porridge. Porridge was made by first mixing 100 g of flour in 300 ml of cold water to make slurry. The slurry was then gradually added, while stirring to 700 ml of boiling water in a 2 L stainless steel saucepan. When the mixture boiled for 5 min, the porridge was removed from the fire, cooled to approximately 60°C and kept in a thermos flask ready for testing. Since the flour for the control porridge was not extruded, it was kept to boil for 20 min, and stirred every 5 min.

Consumer preference test

A surrogate test panel of sixty mothers with average age of 24±8.2 years was recruited for consumer acceptability test from a list of mothers attending the Reproductive and Child Health (RCH) clinic at Magubike Health Centre, Kilosa District, Tanzania. Surrogate mothers who were also the biological mothers were involved in the study due to the fact that the target consumers who are children under the age of five years had no ability to objectively evaluate the sensory quality of the diet formulations. Prior to conducting the sensory tests, mothers were informed about the objectives of the study and requested to give their honest opinions after tasting the food products. Prior to testing, verbal consent was sought from each participant including declaring if they were allergic to any of the food components. Sensory attributes evaluated were colour, smell, texture (mouth feel) taste and overall acceptability using a modified 5-point Hedonic scale in which five and one represented the highest and the lowest orders of preference, respectively. Each panelist was provided with following, serviette, three samples of porridge and mineral water for rinsing the palate before and between testing the samples. During the test, 40-50 ml of porridge was served in 200 ml disposable white cups. After testing the sample, research assistants probed the mothers on the perception of the particular sample and filled the evaluation form.

Training, lexicon development and product evaluation

Product evaluation was carried out following the method described by Lawless & Heymann (2010). Eleven panelists (9 females and 2 males), aged 22-24 years who were final year undergraduate students of the Sokoine University of Agriculture, Morogoro, Tanzania were used. Panelists were selected based on their availability, willingness to participate and knowledge of sensory evaluation. Furthermore, the panelists were screened if they had any of the following defects: taste and odour perception disorders and/or colour blindness. After screening, panelists who were willing to participate in the study signed a consent form to affirm their willingness to participate.

A 1-h training session involving tasting different porridge samples and other foodstuffs in order to generate descriptive terminologies that were used for the study was carried out for 7 days. The panelists individually examined the samples, generated descriptive terms and then discussed the results as a panel. List of nine agreed descriptors (whiteness, colour, sweetness, after taste, mouth feel, aroma, viscosity, liking and oiliness) on a 9 point unstructured line scales and their intensity terms were used in further training sessions (Table 2). Pre-testing was then carried out in order to identify any panelist who was not able to use the developed scale properly. In evaluating the samples, panelists were provided with an evaluation form, a bottle of mineral water, a pen, napkin and three cups of sample porridges for the actual testing.

Ethical clearance

Ethical clearance for this study was obtained from the National Institute for Medical Research (NIMR). Informed consent was obtained from the participants before testing the products.

Statistical analysis

Statistical analyses were done using XLSTAT 2014.06 program. Overall acceptance of the porridge samples was tested by analysis of variance (ANOVA). When p-values were found significant ($p \leq 0.05$), Turkey's HSD-test was performed to determine the individual differences among the three porridge samples. Correlation analysis was also carried out in order to determine the association between different quality attributes of the products. Principal component analysis (PCA) was performed to visualize how the sensory attributes differed across the products.

RESULTS

Consumer evaluation of the porridge samples and preference

Sixty eight percent of the mothers that participated in the study attained primary education while about one third (32%) did not attain any formal education. The average age of the panelists was 28.4±8.5 years. Panelists' rating of the porridges from the different flour formulations is presented in Table 3. It was noted that, extruded porridges required more flour (20% solids by weight) than common maize (7%) in order to make porridge with the same consistency. High scores (>3) were observed in this study for individual attributes and overall acceptability were "like moderately" to "like very much" for all the products. The sensory scores were generally high (4.2 to 4.9) for all attributes of the products, except for taste (3.6) that was observed in conventional porridge (CP). It was also observed that, panelists rated QSB significantly higher ($p<0.05$) than the other porridge samples (QSC and CP) in aroma and taste. Overall, none of the porridge samples was rejected by the panelists. This implied that, the developed products would be liked by consumers if marketed. The data indicated that, CP had slightly higher scores for texture (mouth feel) ($p>0.05$) than the other porridge samples (QSB and QSC). This could partly be attributed to the dehulling, extrusion of the ingredients and subsequent re-grinding of the extrudates. Analysis of variance showed no significant difference ($p>0.05$) in the acceptability of the porridge samples. Therefore, porridges from various flour formulations were equally liked by the panelists.

Quantitative descriptive analysis

Using the lexicon developed, descriptive sensory analysis showed that, extruded porridge samples had significantly ($p<0.05$) more intense colour, mouth feel, whiteness, oiliness and liking, as compared to the conventional porridge (Table 4). Introduction of legumes (soy beans, cowpeas and common beans) and oil significantly

Table 2. Definitions of sensory attributes used in descriptive analysis.

Sensory attributes and their definitions	Reference
Colour	
Colour hue	
Brown	10% cocoa in water
Red	Blood=9
Whiteness	
Degree of white/black in the colour	Snow=9
Taste	
Sweetness	
Basic taste associated with sucrose	10% sucrose in water=9
After Taste	
Aftertaste stimulated by sucrose after 3 minutes	10% sucrose =9
Oiliness	
Taste related to cooking oil	Cooking oil=9
Texture	
Texture	
Degree to which the sample feels smooth and free of lumps/particulates in the mouth	Guava Azam juice®=9
Aroma	
Beany aroma	
Aroma associated with raw bean	Aroma of kidney beans boiled for 30 minutes=9
Viscosity	
Viscosity	
Resistance to flow	Shambani yoghurt® =9

Table 3. Mean sensory scores of QPM-based formulations by test panelists[1,2].

Product	Attributes				
	Aroma	Taste	Mouth feel	Colour	Acceptability
QSB	4.6±0.1[a]	4.6±0.2 [a]	4.7±0.1 [b]	4.9±0.1 [a]	4.7±0.1 [a]
QSC	4.5±0.1 [ab]	4.2±0.2[a]	4.7±0.1 [b]	4.7±0.1 [b]	4.3±0.1 [a]
CP	4.1±0.1 [b]	3.6±0.2[b]	4.9±0.1 [a]	4.7±0.1 [b]	4.2±0.1 [a]
P value	.013	.000	.310	.158	.085

[1]CP: Common maize-based porridge, QSB: Quality protein maize-soybean-common bean, QSC: quality protein maize -soybean-cow peas. [1, 2]Mean values in a column with different superscripts are significantly different at $p<0.05$.

Table 4. Mean sensory attribute scores for three porridge samples[1].

Product	Attributes								
	Aroma	Aftertaste	Mouth feel	Colour	Liking	Sweetness	Viscosity	Oiliness	Whiteness
CP	5.36±1.9	3.45±1.6	7.55±1.1	3.27±1.1	4.36±1.9	3.18±1.9	8.73±0.9	2.27±1.1	5.91±2.0
QSB	6.45±1.9	3.55±2.3	3.64±2.0	6.55±1.0	7.27±1.3	4.18±1.5	8.73±0.5	4.18±2.2	2.91±1.3
QSC	5.64±2.2	3.36±2.0	2.91±1.8	4.64±1.2	7.18±1.1	4.00±1.8	6.73±1.0	4.64±2.7	5.18±1.5
P value	0.422	0.977	.000	.000	.000	0.371	.000	.031	.000

[1]CP: Conventional porridge, QSB: quality protein maize-soybean-common bean, QSC: quality protein maize -soybean-cow peas.

Table 5. Correlation matrix for the sensory attributes of the porridge samples[1].

	Whiteness	Colour	Sweetness	Aftertaste	Mouth feel	Aroma	Viscosity	Liking	Oiliness
Whiteness	1								
Colour	**-0.55**	1							
Sweetness	-0.48	0.265	1						
Aftertaste	-0.089	0.016	-0.149	1					
Mouth feel	0.256	-0.422	-0.144	0.191	1				
Aroma	-0.155	0.017	-0.191	0.418	0.097	1			
Viscosity	-0.14	0.163	0.149	-0.183	0.32	-0.159	1		
Liking	-0.372	**0.566**	0.206	0.296	-0.468	0.384	-0.196	1	
Oiliness	-0.299	0.284	-0.056	0.334	-0.063	0.365	-0.519	0.404	1

[1]Numbers in bold represent significant correlations (p≤0.05).

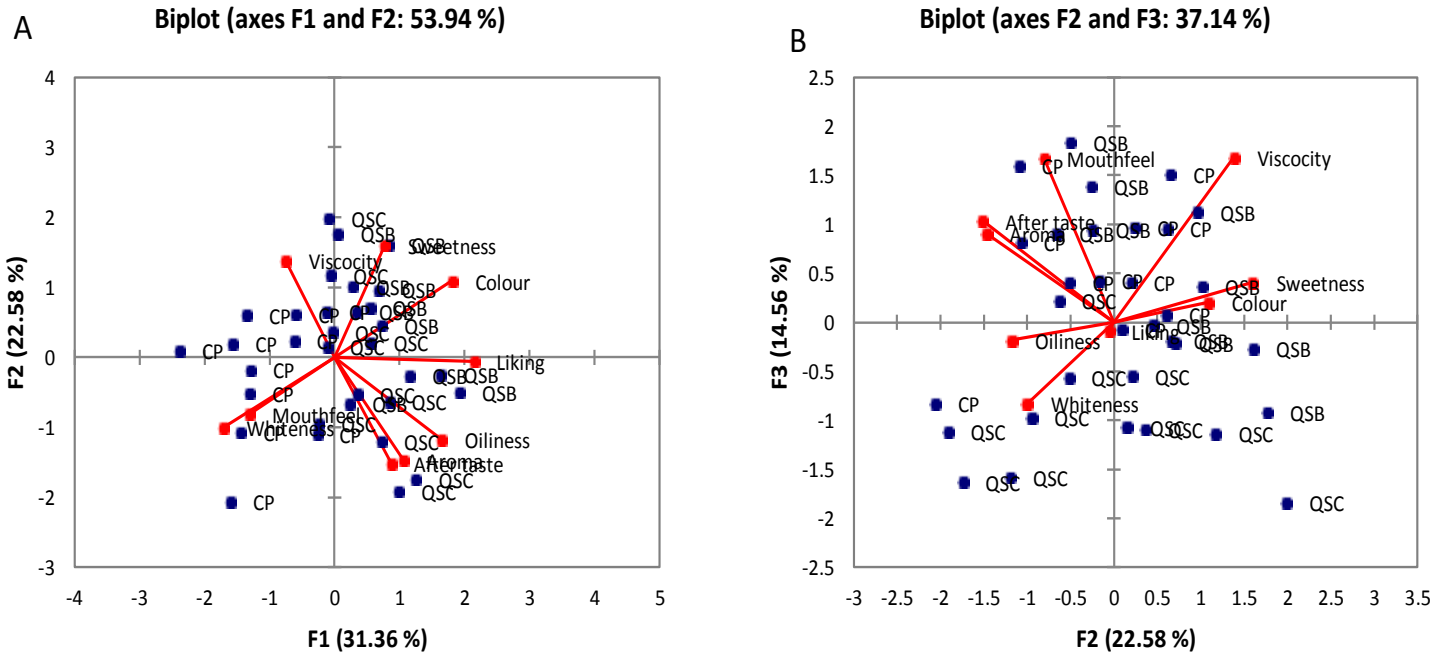

Figure 1. Principal component biplot of descriptive analysis of the three porridge samples; (a) Component factors 1 and 2; (b) Component factors 1 and 3.

(p<0.05) increased creamy flavor, oiliness and mouth feel in the extruded porridges. Porridge sample QSB was significantly more red than the rest. Extruded porridges (QSB and QSC) were less viscous than the CP.

Correlation analysis (Table 5) revealed that, the attributes tested (aroma, taste, mouth feel and colour) were the major determinants of acceptability for the developed products (p<0.000). Taste attribute explained more than 60% of the variation, while the other attributes accounted for less than 50% of the variation. Only few of the tested attributes had significant association. Colour intensity could be associated with 60% of the liking by the panelists. Samples that had higher colour intensity were more likely to score higher liking by the panelists.

Principal component analysis

A two dimensional score plot of principal component analysis (PCA) (PC 1 and 2) indicated that, 54% of the variability was explained on the first two components (Figure 1a). Principal component 1 explained 31.4% of the variability and was characterized by aroma, aftertaste, oiliness, liking, colour and sweetness. These attributes are traditionally considered desirable in porridge. Colour was perfectly negatively correlated with whiteness. This suggested that, increase in colour intensity decreased whiteness. PCA further separated the porridge according to the processing methods. Extruded porridge samples (QSB and QSC) were more loaded in

PC1. Principal component 2 explained 22.6% of the variability and was characterized by viscosity, sweetness and colour. In addition, viscosity was strongly but negatively correlated with aftertaste and aroma. This implied that, as porridge became thick and viscous the aftertaste and aroma intensities decreased.

The findings for PCA 2 and 3 explained 37% of the variability (Figure 1b). PC2 explained 22.6% of the variability and was characterized by colour, sweetness and viscosity. Furthermore, sweetness was negatively related to mouth feel and whiteness, implying that, as sweetness intensity increased, the decreased. PC 3 was characterised by aroma, aftertaste, mouth feel, viscosity, sweetness and colour.

The attribute of loadings for the first two principal components (Figure 1a) showed the relationship between various sensory attributes of the porridge samples. While QSC and QSB were highly loaded on the F1 and F2 components, respectively, CP was highly loaded in both F2 and F3 components (Figure 1a and b). This suggested that, test porridges QSB and QSC were best described by similar sensory attributes (colour, oiliness, aroma, sweetness, liking and aftertaste in the F1 component). All food samples, however, could be described by viscosity, sweetness and colour attributes (in the F2 component) and aroma, aftertaste, mouth feel, viscosity, sweetness and colour intensity attributes (in the F3 component).

ANOVA showed significant variation among the sensory attributes of the porridge samples except for sweetness, aftertaste and aroma (Table 4). CP had higher mouthfeel intensity than QSB and QSC. Sample QSC was less viscous as compared to the other porridge samples. This could be due to the fact that, it had the highest content of protein to starch ratio among the porridge samples. Turkey's post-hoc test indicated that, whiteness intensity was lower ($p<0.05$) in QSB than the other porridge samples. Mouth feel intensity was significantly higher ($p<0.05$) in CP than the other porridge samples. Likewise, CP was significantly more viscous ($p<0.05$) than QSC and QSB. Porridge sample CP had significantly low oiliness intensity ($p<0.05$) than the other porridge samples.

DISCUSSION

Consumer evaluation study

Results from consumer preference study showed that consumer acceptability of the porridge was much dependent on the sensory attributes of porridges namely aroma, taste, mouth feel and colour. Despite the fact that QSB was most preferred in terms of taste and aroma, all porridge samples were equally accepted. The observation that taste and aroma were best predictors of porridge acceptability in the current study, corroborated the findings of Amegovu et al. (2014). The findings that extruded products were more liked by consumers contrasted studies by Muoki et al. (2012) and Ndibalema (2011) who observed that, extruded products were less liked by consumers partly due to the development of volatile flavour compounds during extrusion which were not accustomed to the consumers.

Despite the fact that the test products used about 0.4:0.6 legume: cereal ratio, it did not affect the flavor by introducing beany flavour on the finished products. This could partly be due to extrusion cooking which has been reported to destroy the antinutritional factors and inactivate the lipoxygenase enzymes in legumes which are responsible for the beany flavour development (Singh et al., 2007). Extrusion cooking therefore could produce more nutrient rich foods from plants, a cheap alternative for substituting animal protein. Low viscosity of porridge samples QSB and QSC could be attributed to physical destruction of the starch granules during extrusion associated with mechanical shear and high temperatures during the process. Consequently, there was formation of amorphous water soluble carbohydrates and short chain polymers with low water binding capacities. High protein content in the extruded formulation could have contributed to the low viscosity of the QSB and QSC composites. Blending maize with legumes helped to increase the protein content while decreasing the carbohydrate levels in composite flours (Olapade and Aworh, 2012). This in turn helped to reduce viscosity. Low starch content and low viscosity in maize-legume blends has been reported elsewhere (Amagloh et al., 2012). Due to low viscosity of the formulations, less water was used during porridge preparation than was needed for the control (CP). Therefore, there was low energy and other nutrients density in the CP relative to the other formulations.

Quantitative descriptive study

In this study, panelists demonstrated that, colour intensity was related to liking intensity of the porridge samples. Samples that had higher colour intensity were more likely to score higher liking intensity by judges and vice versa. This finding is in agreement with Mahony (2011) and Nti and Lartey (2007) who observed that, colour intensity was related to liking intensity in peanut paste. The relationship between colour and liking intensity observed in the sensory study was reflected in the consumer evaluation study whereby panelists liked reddish colour of the porridge sample QSB which was caused by red pigmented bean variety used in its formulation. A study by Berhanu et al. (2014) involving the use of red coloured haricot bean in food formulation revealed a change in colour of the finished product that was also associated with increase in customer appeal for the product.

Conclusion

Sensory study revealed that, QSB was ranked highest in

aroma and taste. Other attributes namely mouth feel, colour and acceptability were similar for QSB, QSC and CP. Despite differences in aroma and taste, there was no significant difference in the overall acceptability of the products. This indicated that, all the products were equally preferred by the panelists. Descriptive analysis and consumer testing demonstrated distinctive sensory profiles for QSB, QSC and CP. Regarding consumer acceptability, intensities of oiliness, colour, viscosity, aroma and aftertaste of porridge samples were desirable attributes while viscosity, mouth feel and whiteness were undesirable attributes. It was concluded from this study that, food industry should maintain desirable sensory characteristics and minimize undesirable attributes when formulating products for children. The test products, QSB and QSC showed a great potential for being adopted as supplementary foods for infants and young children.

Conflict of Interests

The authors have not declared any conflict of interests.

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