Production and Quality Evaluation of Complementary Food from Malted Millet, Plantain and Soybean Blends

Islamiyat Folashade Bolarinwa, John Oluranti Olajide, Moruf Olanrewaju Oke, Sulaiman Adebisi Olaniyan, Faromiki Omolara Grace

Abstract— Adequate nutrition during infancy and childhood is vital to proper growth of a child to a healthy adult. At certain age (6-24 months) during infancy, children are fed with complementary food in order to meet up with their high nutrient requirements. Although protein rich complementary foods produced from animal milk are good complementary foods for infant, low nutrient gruels are commonly used as complementary foods in developing countries due to high cost of milk in most developing countries. Infant malnutrition could therefore results from regular consumption of low nutrient gruels. Infant malnutrition can be prevented in developing countries by developing nutritious and cheap complementary foods from nutrient dense locally available crops. In this study, complementary food was produced from locally available cheap crops using local processing methods. The complementary food was formulated from different blends (80:10:10, 60:20:20, 50:20:30, 50:30:20) of malted millet, plantain and soybean. The proximate, mineral, anti-nutrient and sensory properties of the formulated products were determined. The results of proximate analysis of the complementary food blends flour showed increment in protein (9.82-17.09%), ash (1.11-1.46%), fat (6.26-11.05%), fibre (2.72-3.81%) and carbohydrate content (58.99-72.52%) of the complementary food as the ratio of the plantain and soybeans increases in the blends. Similarly; the mineral content of the complementary foods also increases (sodium: 2.80 - 3.18 mg/100g, potassium: 0.4mg/100g – 0.44mg/100g; magnesium: 0.21 – 0.24 mg/100g; iron: 2.22 – 2.51 mg/100g and calcium: 20.11 – 25.10 mg/100g) while the anti-nutrient values decreases (Phytate; 0.20-0.11%, saponin; 3.13-1.41%). Sensory evaluation results showed that the complementary food containing 50% malted millet, 20% plantain and 30% soybean had the most preferred attributes in terms of colour, flavour, mouth feel, appearance and overall acceptability. The developed complementary food formulation could help to alleviate energy-protein malnutrition among infants in developing countries by providing them with adequate nutrients needed for optimum well-being.

Index Terms— anti-nutrients, complementary food, malted millet-plantain-soybean, malnutrition, sensory attributes.

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1 Introduction

Infancy period (0-2 years) is a critical period of children growth, during which they experience optimal growth, health and behavioural development [1]. Breast milk is the most balanced food for infants during their first 6 months [2]. However, the high nutrient requirements of infants after 6 months make breast milk inadequate for them during these periods. Feeding infants with foods that are low in protein and micronutrients can lead to stunt growth. After 2 years of the child's life, it is difficult to reverse stunting that has occurred earlier in their life [3]. Complementary foods are therefore introduced to infant from 6 months to 24 months. In developing countries, complementary foods are usually produced

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traditionally from locally available crops such as cereals, starchy fruits, root and tubers [4], [5]. Infants are mostly fed with gruels that contain low nutrients thus, protein deficiency in the diets is common and it is usually associated with deficiencies in calories and micronutrients leading to endemic protein-energy malnutrition with its attendant health consequences.

In Nigeria, the traditional complementary foods (gruel) are mainly porridges produced from either maize or sorghum or millet which are deficient in energy and other nutrients [6], [7]. In some cases, the gruel may be too watery with low energy density or too bulky, causing reduction in infant consumption rate. Improper feeding during the period of complementary feeding results in infant morbidity and mortality as well as delayed mental and motor development [8]. In order to prevent infant malnutrition and its associated health problems in developing countries, complementary food should be produced from locally available nutrient dense crops. Thus the aim of this study is to produce nutritionally adequate and cheap complementary food from plantain and malted millet supplemented with soybean.

Plantain (*Musa paradisiaca*) is an important starchy staple and commercial crop in the West and Central Africa. About 50% of the world's plantain crop is produced in the West and Central Africa. Plantain is high in carbohydrate and some vital minerals, but low in protein and fat [9]. An average plantain has about 220 calories and is a good source of potassium and dietary fibre [10].They are used as an inexpensive source of calories in Nigeria and other African countries [11] . Plantain can be processed in many ways such as cooking, boiling, steaming, frying, roasting, or can be dried and milled into flour. In Nigeria, plantain is often grated and cooked into porridge [12].

Millet is a tropical crop that produces good yields of grains under unfavourable conditions compared to other crops. It is a good source of some very important nutrients such as copper, manganese, phosphorous, and magnesium [13]. Millets are also rich sources of phytochemicals and other micronutrients [14], [15].

Soyabean (*Glycine max*) is an excellent source of protein (35-40%). It is also rich in calcium, iron, phosphorus and vitamins. It is the only source that contains all the essential amino acids [16]. Apart from being an excellent source of cheap proteins, it also contains all essential fatty acids, magnesium, lecithin, riboflavin, thiamine, fiber and folic acid [17].. Soybeans contain about 3% lecithins which are helpful for the brain development especially, of infants. Soybeans have in addition to lecithins essential minerals [18]. Hence soybean is the richest in food value of all plant foods consumed in the world [19]. It is a legume of major dietary and economic importance in Nigeria.

2 Materials and Methods

Moderately ripe plantain, millet and soybeans

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were purchased from local market in Ogbomoso, Oyo state, South West, Nigeria. All the reagents used in the analysis were of analytical grade. Complementary foods production and chemical analysis of the samples were carried out in Food Processing and Food Chemistry Laboratory, Department of Food Science and Engineering, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria.

Production of malted millet flour

Millet grains were sorted to remove extraneous materials. It was washed and steeped in water for 18 hours and drained. The drained grains were spread on a jute bag, kept in a dark cupboard at ambient temperature (30°C) and watered at intervals for 48 hours to germinate. The malted millet grains were dried in a cabinet dryer at 60°C for 48 hours, after which it was rubbed between palms to remove the sprouts, dry cleaned (air blowing) and milled into flour. The malted millet flour was sieved using a sieve of 250μm aperture size (Fig. 1) to obtain fine flour. The flour was packaged in a low density polyethylene bag and stored at room temperature until used.

Production of plantain flour

The method of [20] with slight modifications was adopted for the production of plantain flour. The plantains were weighed and cleaned using clean water. Thereafter, they were peeled manually, sliced into chips with consistent thickness (5mm) and blanched in hot water (70°C) for 10 minutes. The blanched chips were drained and dried in a cabinet dryer at 100°C for 7 hours. The dried chips were milled into fine flour, sieved using a sieve of 250μm aperture size and then stored in a low density polyethylene bag at room temperature until further used.

Production of soybean flour

Soybean flour was produced according to the method described by [20]. The soybeans were sorted to remove pebbles, stones and other extraneous materials. It was wet cleaned and steeped for 10 hours. The steeped soybeans were drained and precooked for 15 minutes at 100°C after which it was dehulled (by rubbing in between the palms) and the hulls were removed by rinsing with clean water. The dehulled soybeans were dried in the cabinet drier at 100°C for 5 hours and dry milled into fine flour. The soybean flour was sieved using a sieve of 250μm aperture size to obtain smooth flour (Fig. 2). The soybean flour was packaged in a low density polyethylene bag until used.

Formulation of the complementary food

Various percentages of malted millet, plantain and soybean flour were mixed to obtain different blends of complementary foods (Table 1).

Table 1: Formulation of the complementary food

Sample	Un-malted millet flour (%)	Malted millet flour (%)	Plantain flour (%)	Soybean flour (%)
A	0	80	10	10
B	0	60	20	20
C	0	50	20	30
D	0	50	30	20
E	100	0	0	0

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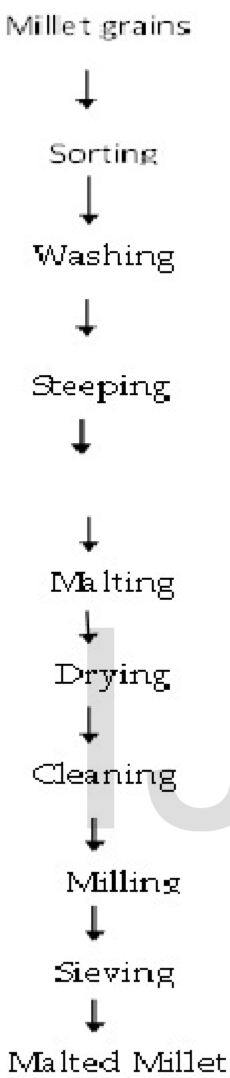

Figure 1: Flow chart for the production of malted millet flour

Chemical Analysis

Proximate analysis was carried out on the complementary food produced from malted millet, plantain and soybean blends. The complementary food samples were analyzed for moisture, ash, crude fibre, protein (N*6.25) and crude fat [21]. Carbohydrate was determined by difference. The minerals; calcium (ca), iron (Fe), and magnesium (Mg) were determined by atomic absorption spectrophotometer while sodium (Na) and potassium (K) were determined using flame photometer [21].

Anti-nutrient determination

The saponin content of the composite flour was determined according to the method described by Ceyhun and Artik [22] while the phytate content was determined by the method described by Latta and Eskin [23].

Preparation of gruel from the formulated complementary food

The complementary food sample (50g) was reconstituted with clean water (100ml). The reconstituted complementary formula was poured in boiling (100^{o}C) water (150ml) in a pot and stirred for 2 to 5 mins to obtain a smooth gruel. Sugar (2g) was added for taste.

Sensory Analysis

Sensory evaluation of the developed complementary foods was carried out by a team of twenty (20) panelists among students of Ladoke Akintola University of Technology, Oyo State. The panellists were

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to determine consumer acceptability of the complementary food samples. They were requested to score the samples according to their degree of likeness using 9 point hedonic scale, where 9 is like extremely and 1 is dislike extremely. The sensory qualities evaluated include; colour, taste, flavour, texture, sweetness, smoothness, mouth feel, appearance and overall acceptability.

Statistical analysis

All data obtained in this study were analysed using SPSS (Statistical Package for Social Sciences) Version 16. Duncan's new multiple range tests was used to compare and separate means. Significance was accepted at $p<0.05$

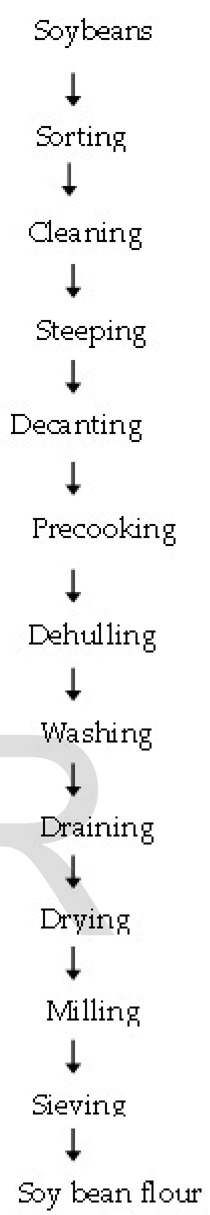

Figure 2: Flowchart for the production of soybean flour

RESULTS AND DISCUSSION

Table 2 shows the proximate composition of the complementary food samples. The result showed that

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sample D recorded the highest value for moisture content (7.97%) while sample A recorded the least moisture content (6.57%). Significant differences were observed in samples A, B and D whereas samples C and E showed no significant difference at $p<0.05$. The moisture content was observed to increase with increasing substitution level of plantain flour in the samples. The high moisture content of the complementary samples could be due to the significant quantity of moisture in plantain. Plantain in its early ripening stage has been reported to contain relatively high moisture (10.55%) content after processing into flour [1]. Similar increased in moisture content with increasing substitution of plantain flour in weaning food produced from sorghum, soybean and plantain was reported by Onoja *et al*. [1].

The protein content of the complementary food samples increased with increasing substitution level of soybean flour in the blends. The significant quantity of high-quality digestible proteins in soybean [24], [25] could be responsible for the increase in the protein content of the complementary food blends, particularly sample C with the highest protein content (17.09%), had the highest percentage substitution with soybeans (30% substitution). There were no significant differences between samples A and E whereas significant differences were observed in samples B, C and D at $p<0.05$. The protein content (17.09%) of the complementary food blend produced from malted millet - plantain - soybean (50: 20: 30) blends (sample C) is higher than the protein content (16.64%) of complementary food formulation made from soybean – millet – guinea corn – maize - groundnut – crayfish (15:20:20:20:10:15) blends but lower than the protein content (18.15%) of complementary food formulation made from soybean - millet – guinea corn - maize-groundnut (20:20:20:20:20) [5]. The variation in the protein content of the complementary food produced in this study and the one produced by Akinola *et al*. [5] could be because of differences in the crops and their combination ratios. However, the crude protein value (17.09%) of one of the developed complementary food sample (sample C) was close to the protein value (20%) recommended by FAO for weaning foods [26]. This indicates that complementary food formulation from malted millet - plantain - soybean (50: 20: 30) will provide infants with the required protein content for proper growth and development.

Ash content is an indication of the amount of minerals in a food sample. The ash content of the complementary food samples increased with increase in the proportion of soybean flour in the sample blends. While there was slight differences in the ash contents of samples B, C and D, significant differences were observed in samples A and E at $p<0.05$. Higher ash content (1.46%) recorded in the sample with the highest soybean ratio (30%) could be due to high ash content in soybean compared to millet (1.11%) and plantain. soybean seeds have been reported to contain an appreciable quantity of minerals [27], [28], [29].

The fat content of the complementary food ranged 8.75 to 11.05%, with sample C having the highest fat content (11.05%) while sample A had the least fat content (8.75%). Significant differences were observed in all the

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samples at p<0.05. High fat content was recorded for sample C probably because of the high proportion of soybean in the blend. Soybean is an oil seed, which has been reported to be a leading source of edible oils and fats [30], [31]. It is also a rich source of essential fatty acids [25]. The fat content of the complementary food samples produced in this study is close to the fat content (8.99%) of nutrend (a commercially-available complementary food in Africa) [32]. The higher fat content could imply good energy levels of the blend containing 30% soybean flour.

The crude fibre content of the complementary food samples ranged from 3.22 to 3.81%. These values are close to the fibre contents (2.0 - 2.5%) of complementary food produced from roasted millet and *Mucuna cochinchinesis* blends [33] but higher than the fibre contents (0.04-2.27%) of complementary food produced from sorghum, plantain and soybean blends [1]. The high fibre content of the three food crops that constitute the complementary food in this study could be responsible for the slightly high crude fibre content of the complementary food. [25] reported that soybean is rich in dietary fibre. Millet was reported to contain about 2.8% crude fibre (Ali *et al*., (2003), while plantain contains 2.3%. However, the fibre content of the developed complementary food is within the range (0.36 - 2.5 %.) reported for infant cereals [34].

The carbohydrate content (59 to 70%) in the complementary food samples was relatively high. The high carbohydrate content in the complementary food blends could be because of the high carbohydrate content of millet and plantain [35], [10]. It was observed that the carbohydrate contents of the complementary food decreased with increasing proportion of soy flour in the complementary food blends. However, the carbohydrate content of the complementary food developed in this study is within the range (30.10 to 87.20%) reported for complementary food from sorghum, plantain and soybean blends [1]. Nelson-Quartey et al. [37] also reported carbohydrate content of 63.5% for infant food produced from breadfruit and breadnut. This value is close to the value of carbohydrate reported in this study. The relatively high carbohydrate content of the formulated complementary food indicates that the food will provide infants with the required calorie.

Table2: Proximate Composition of Complementary Food

Sample	Moisture	Protein	Ash	Fat	Fibre	C
A	6.75±0.03^{a}	9.95±0.08^{a}	1.25±0.02^{b}	08.75±0.11^{b}	3.22±0.04^{b}	70
B	7.41±0.04^{b}	13.57±0.12^{c}	1.37±0.04^{bc}	10.11±0.11^{d}	3.52±0.06^{bc}	63
C	7.60±0.03^{c}	17.09±0.16^{d}	1.46±0.04^{c}	11.05±0.13^{a}	3.81±0.05^{c}	5
D	7.97±0.06^{d}	13.05±0.23^{b}	1.43±0.03^{c}	09.55±0.99^{c}	3.33±0.09^{b}	6
E	7.58±0.03^{c}	09.52±0.00^{a}	1.11±0.05^{a}	06.26±0.25^{a}	2.72±0.26^{a}	7

Values are mean of triplicate determinations. Means with the same superscripts
within the same column are not significantly different (P > 0.05).
A - 80% malted millet, 10% plantain and 10% soybean;
B - 60% malted millet, 20% plantain and 20% soybean;
C - 50% malted millet, 20% plantain and 30% soybean;
D - 50% malted millet, 30% plantain and 20% soybean E-100% un-malted millet.

Mineral composition of the developed complementary food

Table 3 shows the data obtained for the mineral composition of the complementary food which comprises the sodium, potassium, magnesium, iron and calcium

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content of the samples. Complementary food formulation from millet - plantain - soybean (80: 10: 10) blends (sample A) recorded the highest value for sodium content (3.18 mg/100g) while the formulation from millet - plantain – soybean (50:20:30) blends (sample C) had the least sodium value (2.80 mg/100g). Generally, the sodium content of the malted samples was higher than that of the un-malted sample (sample E). However, samples B (60:20:20), C (50:20:30) and D (50:30:20) containing 20, 30 and 20% soybean flour substitutions showed slight decrease in sodium content compared to sample A. This may be due to the increased proportion of soybean in the blends. Grewal and Jood, [38] reported that saponin (which is present in soybean) is known to hinder the availability of mineral like sodium.

The sample with 50% millet, 30% plantain and 20% soybean (sample D) had the highest (0.44 mg/100g) potassium content while 100% un-malted millet flour had the least value (0.36 mg/100g). High value of potassium in sample D could be due to the high proportion of plantain flour in the blend. According to Mepba *et al*., [39] and UNCST [10], plantain is rich source of potassium, containing about 499 mg/100g potassium.

The magnesium content of the complementary food blends (0.22 – 0.24 mg/100g) was slightly higher than that of the 100% un-malted millet flour (0.21 mg/100g). Sample C (50% malted millet, 20% plantain, 30% soybean) recorded the highest value for magnesium content (0.24 mg/100g) while sample E (100% un-malted millet) recorded the least value (0.21 mg/100g). The level of magnesium in sample C was slightly higher than that of the other blends propably because of the high proportion of soybean in the blend. Soybeans have been reported to be an excellent source of magnesium [18].

Sample A (80% malted millet, 10% plantain, 10% soybean) recorded the highest value for iron content (2.51 mg/100g) compare to other samples. High iron level in the sample with the highest proportion of malted millet could be due to the effect of malting on the millet. Malting has been reported to increase in vitro extractability and bio-accessibility of minerals such as calcium, iron, and zinc [40], [30], [41]. There were no significant differences between samples B and C while samples A, D and E showed significant differences at $p<0.05$. The iron content (2.22 – 2.51mg/100g) of the developed complementary food is close to the iron content (2.7 mg/100g) of complementary food formulation from maize-bambara groundnut blend [42]. Regular consumption of food that is rich in iron has the potential of preventing infant anaemia.

Samples A (80:10:10) recorded the highest values for calcium content (25.10 mg/100g) while sample E (100% un-malted millet) recorded the least value of (18.01 mg/100g). The calcium content (20.11 – 25.10 mg/100g) of the formulated complementary food developed in this study is higher than the calcium content (6.44 – 12.14 mg/100g) of gruel produced from complementary food formulated from sorghum, soybean and plantain [1] but lower than the calcium content (42.6 to 53.8 mg/100 g) of weaning food produced from maize and cowpea blend [43]. Calcium is important for proper bone development. Thus, feeding infant with the formulated complementary

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food will promote infant teeth and bone development.

Table 3: Mineral composition of complementary food (mg/100g)

Sample	Sodium	Potassium	Magnesium	Iron	Calcium
A	3.18^{c}	0.42^{d}	0.22^{b}	2.51^{d}	25.10^{e}
B	2.99^{b}	0.40^{c}	0.22^{c}	2.23^{b}	20.23^{b}
C	2.80^{a}	0.41^{c}	0.24^{d}	2.22^{b}	22.02^{d}
D	2.99^{b}	0.44^{e}	0.22^{b}	2.31^{c}	20.11^{c}
E	3.10^{bc}	0.36^{b}	0.21^{a}	2.01^{a}	18.01^{a}

Values are mean of triplicate determinations. Means with the same superscripts
within the same column are not significantly different (P > 0.05).
A - 80% malted millet, 10% plantain and 10% soybean;
B - 60% malted millet, 20% plantain and 20% soybean;
C - 50% malted millet, 20% plantain and 30% soybean;
D - 50% malted millet, 30% plantain and 20% soybean; E-100% un-malted millet.

Anti-nutrients content of the formulated complementary food

Table 4 shows the data obtained for the anti-nutrients content (phytate and saponin) of the complementary food. Sample E (100% un-malted millet) recorded the highest value for phytate content (0.20%) while sample C (50:20:30) recorded the least phytate content (0.11%). The reduction in the phytate content could be due to the effect of malting on the millet when compared to the control sample containing 100% un-malted millet. Reduction in the phytic acid content of millet as a result of malting has been reported by Mamiro *et al*. [40], [30], [41], Udensi *et al*. [33] also reported significant reduction in the phytate content of weaning food produced from roasted millet and *Mucuna cochinchinesis*. The phytate level (0.11 – 0.17 mg/100g) of the formulated complementary food is lower than the phytate level (1.84 – 2.67 mg/100g) of gruel produced from sorghum, soy bean plantain blends [1].

The saponin level of Sample C (50% malted millet, 20% plantain, 30% soybean) was slightly higher than that of the other samples. This could be because of the high soybean proportion in the sample. Saponin is one of the anti-nutritional factors present in soybeans.

Table 4: Anti-nutritional contents of complementary food

Sample	Phytate	Saponin
A	0.17 ± 0.11^{c}	2.16 ± 0.21^{b}
B	0.13 ± 0.00^{b}	3.06 ± 0.21^{c}
C	0.11 ± 0.01^{a}	3.13 ± 0.01^{c}
D	0.16 ± 0.00^{c}	2.69 ± 0.25^{b}
E	0.20 ± 0.01^{d}	1.41 ± 0.01^{a}

Values are mean of triplicate determinations. Means with the same superscripts
within the same column are not significantly different (P > 0.05).
A - 80% malted millet, 10% plantain and 10% soybean;
B - 60% malted millet, 20% plantain and 20% soybean;
C - 50% malted millet, 20% plantain and 30% soybean;
D - 50% malted millet, 30% plantain and 20% soybean; E-100% un-malted millet.

Sensory properties of gruel from the complementary food blends

Table 5 shows the result obtained for the sensory evaluation of the gruel produced from complementary food formulation. The attributes evaluated includes colour, taste, flavour, mouth feel, appearance, sweetness, smoothness and overall acceptability. Sample D had the highest rating in terms of colour (7.30) while sample A had the least rating (4.80). Samples A, B and E showed no significant differences and there were no significant differences ($p<0.05$) between samples C and D . For taste, sample D had the highest rating (6.85) while sample A had the least rating (4.70). There were no significant

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differences ($p<0.05$) between samples B and E.

Sample C had the highest rating for flavour (6.90) while sample A had the least rating (4.85). There were no significant differences observed between samples A, B and E, and samples C and D at $p< 0.05$. Sample C had the highest rating for mouth feel (6.90) while sample A had the least rating (4.90). Slight differences were observed between samples A and B, and sample E while slight differences was also observed between samples C and D at $p<0.05$. For appearance, sample C had the highest rating (6.75) while sample A had the least rating (4.95). There were no significant differences observed between samples A, B and E, and samples C and D at $p< 0.05$.

Sample D had the highest rating for sweetness (6.60) while sample A had the least rating (4.75). There were no significant differences between samples A, B and E, and samples C and D at $p< 0.05$. Sample D had highest rating for smoothness (6.75) while sample A had least rating (5.30). In terms of overall acceptability, sample C had the highest rating (7.20) while sample A had the least rating (5.20). There were no significant differences between samples A and B.

Conclusion

Data obtained in this study shows that nutrient dense complementary food can be produced from blends of cereal, fruit and legume. The complementary food formulation containing 50% malted millet, 20% plantain and 30% soybean was the best in terms of protein, ash and fibre content. It is also rich in minerals. Malting of cereals reduced the viscosity and increased solubility of the gruel produced from the complementary food formulation. The gruel produced from 50% malted millet, 20% plantain and 30% soybean had the most preferred sensory attributes in terms of colour, flavour, mouth feel, appearance and overall acceptability. Feeding infants with the complementary food developed in this study will be a cheap and easy way of preventing infant malnutrition problems in developing countries.

Table 5: Sensory Evaluation of Complementary food

Attributes	Sample A	Sample B	Sample C	Sample D	Sample E
Colour	4.80 ± 1.44^{a}	5.25 ± 1.62^{a}	6.60 ± 1.39^{b}	7.30 ± 1.34^{b}	5.60 ± 1.85^{a}
Taste	4.70 ± 1.95^{a}	5.25 ± 1.83^{ab}	6.25 ± 1.74^{bc}	6.85 ± 1.53^{c}	5.15 ± 1.73^{ab}
Flavour	4.85 ± 1.60^{a}	5.10 ± 1.33^{a}	6.65 ± 1.66^{b}	6.30 ± 1.22^{b}	5.15 ± 1.73^{a}
Mouth feel	4.90 ± 1.68^{a}	5.15 ± 1.84^{a}	6.90 ± 1.62^{c}	6.35 ± 1.35^{bc}	5.50 ± 1.88^{ab}
Appearance	4.95 ± 1.70^{a}	5.20 ± 1.55^{a}	6.75 ± 1.41^{b}	6.60 ± 1.27^{b}	5.35 ± 1.76^{a}
Sweetness	4.75 ± 1.59^{a}	5.30 ± 1.53^{a}	6.40 ± 1.43^{b}	6.60 ± 1.50^{b}	5.05 ± 1.36^{a}
Smoothness	5.30 ± 1.63^{a}	5.25 ± 1.41^{a}	6.30 ± 1.69^{ab}	6.75 ± 1.77^{b}	5.50 ± 1.73^{a}
Overall-Accept	5.20 ± 1.51^{a}	5.50 ± 1.43^{a}	7.20 ± 1.61^{c}	6.55 ± 1.43^{bc}	5.60 ± 1.79^{ab}

Values are mean of triplicate determinations. Means with the same superscripts within the same column are not significantly different ($P > 0.05$). A - 80% malted millet, 10% plantain and 10% soybean; B - 60% malted millet, 20% plantain and 20% soybean; C - 50% malted millet, 20% plantain and 30% soybean; D - 50% malted millet, 30% plantain and 20% soybean; E-100% un-malted millet.

References

[1] U.S. Onoja, P.I .Akubor, D.I. Gernar, C.E. Chinmma . Evaluation of Complementary Food Formulated from Local Staples and Fortified with Calcium, Iron and Zinc. *J Nutr Food Sci.*, vol. 4, pp. 326. 2014

[2] WHO. The optimal duration of exclusive breastfeeding: report of an expert consultation. Geneva, World Health Organization, (WHO/NHD/01.09, WHO/FCH/CAH 01.24). 2001.

[3] Martorell R, Kettel L, Schroeder G. Macro level approaches to improve the availability of complementary foods. *Food Nutrition Bulileti*n, New York. 1994.

[4] F.M. Makinde,. and A.T. Ladipo, Physico-chemical and microbial quality of sorghum-based complementary food enriched with soybean (*Glycine max*) and sesame (*Sesamum indicum*). *J. food Technology*, vol. 10, no. 2, pp. 46-49. 2012.

[5] O.O., Akinola, O.P. Opreh, and I.A. Hammed. Formulation of local ingredient-based complementary food in South-west Nigeria. IOSR *J. Nursing and Health Science*, vol. 3, pp. 57-61. 2014.

[6] U.S. Onoja, I.C. Obizoba, Nutrient composition and organoleptic attributes of gruel based on fermented cereal, legume, tuber and root flour. *J Trop Agric Fd Environ Ext* vol. 8, pp. 162-168. 2009.

[7] P.A. Yusufu, F.A. Egbunu, S.I.D Egwujeh, G.L Opega, M.O. Adikwu, Evaluation of Complementary Food Prepared from Sorghum, African Yam Bean (Sphenostylis stenocarpa) and Mango Mesocarp Flour Blends. *Pak J Nutr* vol. 12, pp. 205-208. 2013.

[8] N.F. Krebs, K.M. Hambidge, Complementary feeding: clinically relevant factors affecting timing and composition. *Am J Clin Nutr* vol. 85, pp. 639-645. 2007.

[9] R . Swennen. Plantain cultivation under West African condition. A Reference Manual, Institute of Tropical Agriculture (IITA). pp. 1-24. 1990.

[10] UNCST. The biology of bananas and plantains. Uganda National Council for science and Technology in collaboration with PBS- a US Agency for International Development.p.1-17. 2007. http://www.biovisioneastafrica.com/publications/BIOLOGY%20OF%20BANANAS%20AND%20PLANTAINS-BZ%20Jul07.pdf

[11] P.I. Akubor, F.O. Adamolekun, C.O. Oba, H .Obari, I.O. Abudu. Chemical composition and functional properties of cowpea and plantain flour blends for cookie production. *J. Plant Foods for Human Nutrition*, vol. 58, no. 3, pp. 1-9. 2003.

[12] M. I. Dosunmu, and F. I. Bassey, A comparative study of the starch pasting properties of unprocessed and processed cassava (Manihot esculenta), plantain (*Musa paradisiaca*) and banana (*Musa sapientum*) flours. *Global J. Pure Appl. Sci.* vol. 9, pp. 517–522. 2003.

[13] J.N.C. Okafor, A.U. Ozumba, L.I. Osibanjo, A.M. Onu, N.D. O.O. Daodu, Olatunji, Chemical Foods from Blend of Nigeria Food Stuff. *J. Ind. Technol.*, vol. 2, pp. 31 – 36. 2008.

[14] P. Singh, R.S. Raghuvanshi, Finger millet for food and nutritional security. *Afr. J Food Sci*., vol. 6, no. 4, pp. 77–84. 2012.

[15] K.P. Singh, A .Mishra, H.N. Mishra.. Fuzzy analysis of sensory attributes of bread prepared from millet-based composite flours. *LWT—Food Sci Technol*, vol. 48, pp. 276–82. 2012.

[16] A.I. Ihekoronye, and P.O. Ngoddy, Integrated Food Science and technol, for the tropics. 1st Edn., McMillan publishers. pp. 261-291.

[17] McWatters, K. H., A. V. A. Resurreccion, L. R. Beuchat, and R. D. Phillips. (1995). Use of soybean and cowpea in wheat-based products containing composite flours. *Plant Foods Hum. Nutr*. vol. 47, pp. 71–87. 1985.

[18] H.Y. Jiang, F.J. Lv, J.Q. Tai, Bioactive components of soybeans and their functions. *Soybean Science.* vol. 19, pp. 160-164. 2000.

[19] O.A. Kure, E.J. Bahago and E.A. Daniel, Studies on the proximate composition and effect of flour particle size of acceptability of biscuits produced from blends and plantain flours. *Namoda Tech. Scope J.*, vol. 3, pp. 17-22. 1998.

[20] C.N. Nwakalor and C.D. Obi, Formulation and Sensory Evaluation of Sorghum Based Weaning Food Fortified with Soybean and Unripe Plantain Flour. *International Journal of Nutrition and Food Sciences.* vol. 3, no. 5, pp. 387-390. 2014.

[21] AOAC, Official Methods of Analysis (15th edition), Association of Official Analytical Chemists. 2003.

[22] A.E.Ceyhun, and N. Artik, Determination of Saponin content in Turkish Tahini Halvah by using HPLC. *Advance Journal of Food Science and Technology*, vol. 2, no. 2, pp. 109-115. 2010.

[23] M. Latta and M.A. Eskin. Simple and rapid colorimetric method of phytate determination. *J. Agric Food Chem.* Vol. 29, pp. 315–317. 1980.

[24] F.Q. Mendes, M.G.A. Oliveira, L.C. Cardoso, N.M.B Costa, R.C.O Sant'Ana, Digestibilidade proteica e caracterização bromatológica de linhagens de soja com ausência ou presença do inibidor de tripsina Kunitz e das isozimas lipoxigenases. *Journal of Biosciences*, vol. 23, pp.14-21. 2007.

[25] E.A. Esteves, H.S.D Martino, F.C.E Oliveira, J .Bressan, N.M.B Costa, Chemical composition of a soybean cultivar lacking lipoxygenases (LOX2 and LOX3). *Food Chemistry*, vol. 122, no. 1, pp. 238-242. 2010.

[26] FAO. Food and Agrigulrure Organisation. Grain Legumes in Africa. 3rd edition, Food and Agricultural Organization, Rome. pp. 82 - 83. 1996.

[27] C.C. Ariahu, U. Ukpabi, K.O. Mbajunwa, Production of African breadfruit (Treculia Africana) and soybean (Glycine max) seed based food formulations: Effects of germination and fermentation on nutritional and organoleptic quality. *Foods for Human Nutr*. vol. 54, no. 3, pp. 193-206. 1999.

[28] U. Onyeka and I .Dibia, Malted weaning food made from maize, soybean, groundnut and cooking banana. *J. Sci. Food and Agric*. vol. 82, no. 5, pp. 513-516. 2002.

[29] W.A. Plahar, B.O. Okezie, C.K. Gyato. Development of a high protein weaning food by extrusion cooking using peanuts, maize and soybeans. *Plant Foods for Human Nutr*. vol. 58, no.3, pp. 1-12. 2003.

[30] P.F. Suma, A. Urooj, Influence of germination on bioaccessible

iron and calcium in pearl millet (*Pennisetum typhoideum*). *Journal of Food Science and Technology*, vol. 51, no.5, pp. 976-981. 2011.

[31] M.O. Alabi, J.C. Anuonye., C.F. Ndaeji and A.A .Idowu, Comparison of the growth and development of selected children in soybean and non-soybean producing and utilization of villages in Niger State, Nigeria. Poly Math J., 2: 8-12. 2001.

[32] T.W. Fagbemi and A.A. Oshodi, Chemical Composition and Functional Properties of Full Fat Fluted pumpkin Seed Flour. *Nig. Food J*. vol. 9, pp. 26 - 31. 1991.

[33] E.A. Udensi, T .C. Odom, O.J Nwaorgu, R.O. Emecheta and C.A. Ihemanma, Production and evaluation of the nutritional quality of weaning food formulation from roasted millet and Mucuna cochinchinesis). *Journal of Food Science,* vol.1, no. 1, pp. 1 – 5. 2012.

[34] W.F. Geddes and R.A. Stewart, Cereals for Infants in Nutritional Evaluation of Food Processing. 3rd Edition. AVI Publishing Co. Inc. Westport Connecticut, pp. 229. 1973.

[36] M.A.M. Ali, A.H. El Tinay and A.H. Abdalla, Effect of fermentation on the in vitro protein digestibility of pearl millet. *Food Chem*. Vol. 80, no. 1, pp. 51–4. 2003.

[37] F.C. Nelson-Quartey, F.K. Amagloh, I.N. Oduro and W.O. Ellis, Formulation of an infant food based on breadfruit (*Artocarpus altilis*) and breadnut (*Artocarpus camansi*). *Acta Hort (ISHS*), vol. 757, pp. 215-224. 2007.

[38] A. Grewal and S. Jood, Effect of processing treatments on nutritional and antinutritional contents of green gram. *J Food Biochem*., vol. 30, pp. 535–46 2006.

[39] H.D. Mepba, L. Eboh, and S.U. Nwaojigwa, Chemical composition, functional and baking properties of wheat-plantain composite flours. Afric. *J. Food Agric. Nutri. Dev*. Vol. 7, no. 1, pp.1-22. 2007.

[40] P.R.S. Mamiro, J. Van Camp, S.M. Mwikya, A. Huyghebaert, In vitro extractability of calcium, iron, and zinc in finger millet and kidney beans during processing. *J Food Sci.* vol. 66, pp.1271–5. 2001.

[41] R . Krishnan, U. Dharmaraj, N.G. Malleshi, Influence of decortication, popping and malting on bioaccessibility of calcium, iron and zinc in finger millet. *LWT—Food Sci Technol*. Vol. 48, pp. 169–74. 2012.

[42] P. O. Uvere, E. U. Onyekwere, P. O. Ngoddy, Production of maize–bambara groundnut complementary foods fortified pre-fermentation with processed foods rich in calcium, iron, zinc and provitamin A. *J Sci Food Agric*. vol. 90, pp. 566–573. 2010.

[43] C.A. Nti, and W.A. Plahar, Chemical and biological characteristics of a West African weaning food supplemented with cowpea (*Vigna unguiculata*). *Plant Foods Hum. Nutr.*, vol. 48, no.1. pp. 45-54. 1995.