Production and characterization of complementary food produced from orange fleshed sweet potato, soybean and sorghum flour

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Abstract: Traditional complementary foods are mainly based on cereal grains which when cooked got gelatinized and swollen thereby making the diet viscous and bulky for infants and young children. This study was carried out to develop and evaluate a complementary food from Orange Fleshed Sweet Potato (OFSP), soybean, and sorghum with a view of producing nutrient dense complementary food. Steam blanched OFSP, dehulled soybean and sorghum were blended in different ratios to form paste before air drying at 55°C to 10% moisture content., The dried blends were milled and sieved to pass through 450 µm sieve size to obtain fine flour samples. The obtained formulated five samples were analyzed for chemical components, functional properties, and sensory attributes. The obtained data were subjected to analysis of variance to establish significant difference at $p<0.05$, while Duncan multiple range test was used to separate mean. Results showed that the crude protein value of samples ranged from 16.79 to 18.30 g/100g. The fat content of the complementary food samples ranged from 12.84 to 14.25 g/100g. The result for β-carotene content of the complementary food samples ranged from 3193 to 3357 IU. The study revealed that an acceptable and nutrient dense complementary food could be produced from the combination of Orange Fleshed Sweet Potato, soybean and sorghum.

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1. Introduction

Nutritional status in children is most vulnerable during the weaning stages when both macro and micronutrients may be insufficient to maintain growth and development of the child, thus leading to protein energy malnutrition (Onabanjo et al., 2008). This has led to infant and young children malnutrition. The resultant nutritional deficiencies such as under-weight, wasting, and stunting has led to increase effort in research development and extension by both local and international organizations. These research efforts focus on improving the nutritional quality in terms of energy, protein, and micronutrients of complementary foods specifically traditionally produced complementary foods (Igyor et al., 2010). Inclusion of soybean flour in various complementary food formulations for indigenous materials improved the protein quality, but not the vitamin A status (Omueti et al., 2000). Vitamin A deficiency (VAD) is a major public health nutrition problem; affecting an estimate of 190 million (approx. 33%) pre-school aged children and 19 million pregnant and lactating women worldwide (Klemm et al., 2000).

Infants, young children and pregnant women especially in low income countries such as Nigeria are more susceptible to VAD due to under-nutrition, consumption of low vitamin A rich foods (Martin et al., 2010). This deficiency has far reaching consequences, as it increases the risk of diarrhea, children risk to common illness, and impairs children growth, development, vision and immune systems (Future harvest 2004; Mayo-Wilson et al., 2011). It is thus, a priority, important in health policy to improve vitamin A and pro-vitamin A status in these vulnerable groups especially children (Future harvest, 2004). Health organizations had supported the fight against vitamin A deficiency through the promotion of orange fleshed sweet potato (OFSP) as a dietary source of β-carotene, for which the body synthesizes the vitamin, most importantly in rural areas where majority of people are poor (Tumwegamire et al., 2004; Jaarsveld et al., 2005). OFSP has considerable potential to contribute to a food-based approach to tackle the problem of vitamin A deficiency (Low et al., 2007). This study, therefore attempted to do a preliminary study on development and evaluate the quality characteristics of a complementary food from OFSP (*Ipomoea batatas*), soybean (*Glycine max*) and sorghum (*Sorghum bicolor*).

2. Materials and Methods

The OFSP was procured from the Polytechnic, Offa demonstration farm, while soybean and sorghum used in this study were purchased at Owode market, Offa, Kwara State, Nigeria.

2.1 Materials

2.2 Preparation of mashed orange fleshed sweet potato sample

The OFSP was sorted out, washed and weighed. The weighed OFSP were peeled and sliced into small cubed. The sliced OFSP was again washed thoroughly and steam blanched for 10 min. It was then mashed with an already cleaned pestle and mortal to obtain mashed OFSP. The mashed OFSP was stored at room temperature (30 ± 2^{o}C) in an airtight low-density polyethylene bag for analysis.

2.3 Preparation of soybean flour sample

Soybean flour was prepared by the method described by Ihekoronye & Ngoddy (1985). Soybean was sorted to remove particles, defective seed and stones before cleaning thoroughly washed in clean water. The seeds were boiled for 20 mins and drained to inactivate trypsin inhibitors followed by dehulling with hands rubbing after which the soybean cotyledons were dried in hot air oven at 70^{o}C for 10 mins. It was then milled using laboratory hammer mill (Fritsch, D-55743, Idar-Oberstein, Germany) to fine powder and sieved through a standard sieve (250 μm) and stored at room temperature (30 ± 2^{o}C) in an airtight low-density polyethylene bag for analysis.

2.4 Preparation of sorghum flour sample

Sorghum grains were sorted to remove particles, defective seed and stones before cleaning thoroughly washed and soaked at room temperature (30 ± 2^{o}C) in clean water for 4 hrs to remove some its inherent antinutritional factors. The seeds were dried in hot air oven at 55^{o}C for 48 mins. It was then milled using laboratory hammer mill (Fritsch, D-55743, Idar-Oberstein, Germany) to fine powder and sieved through a standard sieve (250 μm) and stored at room temperature (30 ± 2^{o}C) in an airtight low-density polyethylene bag for analysis.

2.5 Formulation of the complementary food

The standard values of (FAO/WHO, 2002) for formulation of complementary food in vitamin A (retinol equivalents, 400 mg RE), protein content (15 – 20 g), fat (10 – 25 g), crude fiber (< 5%), and total energy (≥400 kcal/100g) was taken into consideration when the complementary foods were formulated. The OFSP mashed, soybean and sorghum flours obtained were mixed in different ration to form each sample paste, respectively. All the pastes were transferred to aluminum trays, dried in an air oven at 55^{o}C for 48 hrs to bring the moisture content to about 10 - 12%. The dried samples were milled using a locally fabricated milling machine and sieved with a mesh size of 250 μm. The flours obtained were stored at room temperature (30 ± 2^{o}C) in an airtight low-density polyethylene bag for analysis.

2.6 Determination of chemical properties

The determination of proximate composition of the complementary food samples and energy content of the sample was obtained according to method of (AOAC, 2005). In the determination of β-carotene, the samples were determined according to the method described by (Dubois et al., 1956), while the method described by (WHO/UNICEF, 1988) was used to calculated vitamin A.

2.7 Determination of functional properties

Bulk density was determined by the method of Wondimu & Malleshi (1996), while wettability index was done according to the procedure described by Okezie & Bello (1988). Dispersibility was carried out according to method described by Kulkarni et al. (1991). The method of Beuchat (1977) was used for the determination of oil absorption capacity, while water absorption capacity was determined using the method described by Sosulski (1962). The swelling power of each sample was determined using the method of Leach et al. (1959).

2.8 Sensory evaluation of the complementary food

The complementary food samples were prepared into gruel and presented to twenty semi-trained nursing mothers. Each sample was reconstituted, coded, and evaluated for preference using the method of Iwe (2002). They were asked to score the complementary food samples for colour, taste, aroma, slipperiness, and overall acceptability. Each panelist sat in an enclosed cubicle designed for sensory evaluation and water was provided to rinse mouths before and after tasting each of the samples. The panelists were presented with a score sheet using 9-point hedonic scale where 1 is disliked extremely and 9 liked extremely.

2.9 Statistical Analysis

All data were statistically analyzed using SPSS version 17.0 for analysis of variance, while Duncan multiple range test (DMRT) was used to separate means where there is a significant difference. For each sample, triplicate determinations were carried out.

3. Results

3.1 Chemical properties of the complementary food samples

Table 1 presents the chemical composition of the complementary foods. Moisture content of the samples ranged from 7.88% for sample E to 10.24% for sample A. There were significant differences ($p< 0.05$) in the moisture content of the complementary foods. The crude protein value of samples ranged from 16.79 g in sample A to 18.30 g in sample E. The fat content of the complementary food samples ranged from 12.84 g in sample A to 14.25 g in sample E while ash content of the complementary food samples ranged from 2.85 g in sample A to 3.24 g in sample E. The study results revealed that crude fiber level of samples ranged from 1.39 g in the sample A to 1.71 g in sample D. The percentage carbohydrate of the complementary foods ranged from 54.02 in sample C to 56.90 in sample B which is lower than compared to 66.50 of the commercial brands used in the study. Energy value of the complementary food samples ranged from 406.28 kcal/100g in sample A to 420.85 kcal/100g in sample E. The result for β-carotene (pro-vitamin A) content of the complementary food samples ranged from 3193 IU/100g in sample D to 3357 IU/100g in sample B.

Table 1: Chemical properties of the complementary food

Sample	Moisture Content	Crude protein	Parameter/100g Crude fat	Crude ash	Crude fibre	Carbohydrate	Energy, kcal/100g	β-carotene	Cal. Vitamin A (RE*)
A	10.24 ± 0.47^{d}	16.79 ± 0.30^{a}	12.84 ± 0.21^{a}	2.85 ± 0.01^{a}	1.39 ± 0.00^{a}	55.89 ± 0.38^{ab}	406.28 ± 1.43^{a}	3196.4 ± 0.62^{a}	532.73 ± 0.53^{a}
B	8.14 ± 0.32^{bc}	17.53 ± 0.11^{ab}	13.06 ± 0.09^{ab}	2.97 ± 0.27^{a}	1.40 ± 0.14^{a}	56.90 ± 0.63^{bc}	415.26 ± 0.89^{c}	3357.17 ± 0.81^{c}	559.53 ± 0.99^{c}
C	9.93 ± 0.08^{cd}	17.93 ± 0.32^{bc}	13.48 ± 0.49^{b}	3.11 ± 0.00^{b}	1.53 ± 0.07^{bc}	54.02 ± 0.92^{a}	409.12 ± 1.05^{ab}	3271.4 ± 0.08^{b}	545.23 ± 0.17^{b}
D	9.27 ± 0.61^{c}	17.88 ± 0.41^{b}	13.81 ± 0.28^{bc}	3.22 ± 0.32^{b}	1.71 ± 0.03^{c}	54.11 ± 0.38^{a}	412.25 ± 0.76^{b}	3192.5 ± 1.32^{a}	532.08 ± 0.82^{a}
E	7.88 ± 0.26^{a}	18.30 ± 0.22^{c}	14.25 ± 0.36^{d}	3.24 ± 0.18^{bc}	1.48 ± 0.20^{a}	54.85 ± 0.44^{a}	420.85 ± 0.68^{d}	3269.8 ± 0.95^{b}	544.97 ± 1.20^{b}
F	N.D	15.00	10.00	3.25	2.00	66.50	416.00	1300.0	216.67

All the samples were in ration of OFSP, soybean, and sorghum, respectively. Sample A: 80:16:04; Sample B: 76:19:05; Sample C: 72:22:06; Sample D: 67:28:05; Sample E: 64:27:09; Sample F: Control [Cerelac™]; N.D: Not determined. *: 6μg of β-carotene equal 1 retinol activity equivalent and 1 retinol equivalent of vitamin A activity equivalent to 1μg of retinol [11]. All values are expressed as mean ± SD of three replicate determinations. Mean values in the same column with different superscript are significantly different ($p < 0.05$).

3.2 Functional properties of the complementary food samples

The functional properties of the complementary food samples are as presented in Table 2. Bulk density of the complementary food samples ranged from 0.56 g/cm^3 in sample E to 0.70 g/cm^3 in sample D. There were no significant differences ($p>0.05$) in bulk densities of the complementary food with values between 0.56 and 0.70 g/cm^3. The complementary food samples were also significantly different ($p<0.05$) in their wettability and dispersibility. The values ranged from 10.63 to 25.54 sec and 63.50 to 70.25% for wettability and dispersibility, respectively. The oil absorption capacity (OAC) and water absorption capacity (WAC) values of the complementary foods were significantly different at alpha 0.05. There values ranged from 1.60 to 2.00% and 2.37 to 3.40 g/100g for wettability and dispersibility, respectively. All the complementary food samples were significantly different ($p<0.05$) in their swelling capacity. Flour from sample E had the lowest swelling power (1.96 g/100g), while sample A had the highest (4.82 g/100g) value.

Table 2: Functional properties of the complementary food samples

Sample	Bulk density, g/cm^3	Wettability, s	Parameter/100g Dispersibility, %	OAC, g/g	WAC, g/g	Swelling index
A	0.67 ± 0.14^{bc}	10.63 ± 0.13^{a}	65.75 ± 1.44^{ab}	1.60 ± 0.00^{a}	3.40 ± 0.24^{c}	2.92 ± 0.18^{b}
B	0.62 ± 0.01^{b}	11.78 ± 1.26^{ab}	68.75 ± 1.37^{bc}	1.80 ± 0.24^{ab}	3.10 ± 0.20^{bc}	2.74 ± 0.05^{b}
C	0.63 ± 0.22^{b}	25.54 ± 2.97^{e}	63.50 ± 0.21^{a}	1.64 ± 0.19^{a}	2.80 ± 0.17^{b}	2.68 ± 0.11^{b}
D	0.70 ± 0.06^{d}	14.91 ± 0.98^{cd}	70.25 ± 2.76^{c}	1.64 ± 0.34^{a}	2.45 ± 0.09^{a}	2.63 ± 0.23^{b}
E	0.56 ± 0.18^{a}	18.78 ± 0.71^{d}	68.00 ± 0.14^{bc}	2.00 ± 0.02^{bc}	2.37 ± 0.31^{a}	1.96 ± 0.03^{a}
F	N.D	N.D	N.D	N.D	N.D	N.D

All the samples were in ration of OFSP, soybean, and sorghum, respectively. Sample A: 80:16:04; Sample B: 76:19:05; Sample C: 72:22:06; Sample D: 67:28:05; Sample E: 64:27:09; Sample F: Control [Cerelac™]; OAC: Oil Absorption Capacity; WAC: Water Absorption Capacity; N.D: Not determined. All values are expressed as mean ± SD of three replicate determinations. Mean values in the same column with different superscript are significantly different ($p < 0.05$).

3.3 Sensory attributes of the complementary food samples

Table 3 presents the sensory attributes of the complementary foods. In term of colour, sample A had the highest mean score (7.08) and was significantly preferred ($p<0.05$) to other complementary food samples. The data of sensory attributes obtained showed that the gruel of sample A tastes better and had the next highest mean score for flavour (6.04) when compared with other complementary flours. The formulated complementary food sample B was highly acceptable by the trained panelists with mean scores of 7.54

Table 3: Sensory attributes of the complementary food samples

Sample	Colour	Taste	Aroma	Slipperiness	Overall Acceptability
A	7.08 ± 0.34^{d}	6.12 ± 0.31^{b}	6.04 ± 0.53^{b}	6.32 ± 0.22^{a}	6.70 ± 0.41^{b}
B	6.70 ± 0.17^{cd}	6.25 ± 0.40^{b}	6.23 ± 0.50^{b}	6.60 ± 0.26^{b}	7.54 ± 0.24^{cd}
C	6.63 ± 0.32^{b}	5.86 ± 0.47^{a}	5.94 ± 0.46^{b}	6.35 ± 0.20^{a}	6.71 ± 0.45^{b}
D	6.27 ± 0.34^{a}	5.73 ± 0.33^{a}	5.59 ± 0.19^{a}	6.26 ± 0.21^{a}	6.19 ± 0.38^{a}
E	6.56 ± 0.03^{a}	5.64 ± 0.42^{a}	5.99 ± 0.17^{b}	6.34 ± 0.20^{a}	6.55 ± 0.42^{a}
F	8.02 ± 0.06^{e}	7.58 ± 0.07^{c}	7.88 ± 0.34^{c}	7.74 ± 0.36^{c}	8.04 ± 0.18^{d}

All values are expressed as mean ± SD of three replicate determinations. All the samples were in ration of OFSP, soybean, and sorghum, respectively. Sample A: 80:16:04; Sample B: 76:19:05; Sample C: 72:22:06; Sample D: 67:28:05; Sample E: 64:27:09; Sample F: Control [Cerelac™]. Mean values in the same column with different superscript are significantly different ($p< 0.05$).

Discussions

Moisture content of the food or processed product gives indication of its shelf-life and nutrition concentration. Low moisture content is a requirement for longer storage ability (Zakpaa et al., 2010). The moisture content of the study samples is related to its dry matter content and therefore to the yield obtained from a crop. The study protein values are greater than the recommended value (13 – 14 g/100g) of Anigo et al. (2009) and the commercial complementary food compared (Cerelac™) while the fat content of all the samples provide about 28.43% of the energy value which is greater than the value recommended by FAO/WHO (1994). Ash content is the organic residue remaining after an organic matter has been burnt off, and it specify indirectly the amount of mineral content present in the sample. There is significant difference ($p<0.05$) in total ash content of the complementary food samples especially samples C – E and the commercial brand used in this study however, it is still within the recommended value of ≤ 5% Codex Standard (FAO/WHO/UNU, 1985; Zlotkin et al., 2010). The crude fiber values were like the value recorded for cowpea reported by (Padmashree et al., 1987). The low crude fiber content of the complementary food sample will enhance nutrients availability and absorption especially for children as reported by (Agbon et al., 2013).

The total energy content of the samples E was slightly higher than the commercial brand (416.0 kcal/100g). All the complementary food samples in this study could supply more than the recommended value of 13% (energy from fat) for old infant and young children. The Codex Alimentarius guidelines for formulated complementary food for older infants and young children according to FAO/WHO (1994) proposed that an energy density of at least 13% of total energy should come from crude fat of the complementary food. The energy that would be obtained from crude fat of the complementary foods ranged from 28.44 to 30.47%. Dewey & Brown (2003) and Onabanjo et al. (2008) reported that should the breast milk have a low-fat concentration, as may happen in developing countries, infants need an additional 10 – 24% of the energy from fat and by the time infants reach 9 months of age, their complementary food diet should provide 13% of the energy from fat. There was no significant increase ($p>0.05$) in the crude fiber, and carbohydrate content of the complementary food samples. Samples beta carotene were higher than 1300 IU/100g of the commercial brand used in this study. OFSP may have contributed to the high level of the β-carotene of the complementary food samples. Research has shown that OFSP contain more than 50-fold more β-carotene, which can be converted to vitamin A in the stomach after ingestion than the yellow or white varieties commonly eaten in African countries. β-carotene rich foods are important for preventing vitamin A deficiency (Jaarsveld et al., 2005; Low et al., 2007). Consumption of meals containing β-carotene rich OFSP would increase serum retinol concentrations in marginal vitamin A deficient children (Future harvest, 2004; Low et al., 2007). In many developing countries, the adoption of sweet potato as a staple food may play a major role as a food-based approach in controlling vitamin A deficiency.

Changes in functional properties during or with processing method required prompt and technical attention to produce food product that would be acceptable by the end-users. Low bulk density of food products had been reported to provide nutrient dense meal for infants and young children, as more of the products can be eaten resulting in high nutrient intake per meal for the baby (Nnam, 2000; Riaz-Mian & Swanmylingappa, 2006). Bulk density could also be affected by moisture content and reflects particle size distribution of the complementary flours (Wadud et al., 2004). The wettability and dispersibility results agree with the earlier reports of Ezeocha & Onwuka (2010) who worked on complementary foods based on cereals and legumes (maize-soybean) and reported that wettability and dispersibility of the soybean based complementary foods were significantly affected by processing method used.

Low oil absorption is highly desirable for flour product, which indicates the amount of oil that must be taken up a given weight of dry pigment in order to form a paste, while low water absorption could be due to high proportion of hydrophilic group and amino acid of the protein molecule and the increase may be due to the binding properties of the protein in the flour (Greta & Sheghah, 2010). Prinyawiwatkul et al. (1997) reported that the increase in WAC of heat processed cowpea flour may have been due to changes in concentration and structural conformation of proteins. The water absorption capacity (WAC) observed in this study is probably related to the low viscosity patterns and weak internal organization resulting from starch granules as reported by Singh et al. (2003) who worked on cookie-making properties of corn and potato flours.

Riaz-Mian & Swanmylingappa (2006) reported that high water absorption is desirable in food system to improve yield and consistency of such food. Generally, the low level of swelling power obtained for the samples may have been caused by the hydrolyzed starch which swells less, retains less water and has lower viscosity, and increases the nutrient and energy densities per unit volume of the blended flour. Swelling index is largely controlled by the strength and character of the micellar network within the granules (Riaz-Mian & Swanmylingappa, 2006; Adebowale et al., 2005).

The high mean score obtained for the sensory attributes showed that all the formulated complementary foods were acceptable to the panelists. Obatolu & Cole (2000) reported that compatibility of functional properties of food ingredients when mixed together has been shown to determine food acceptability of soybean and cowpea with malted and unmalted maize complementary foods. Walker & Pavitt (2007) reported that the presence of sugar in complementary foods commonly improve flavour and encourage infants to eat, while fat acts as flavour retainer and increases mouth feel. The authors also reported that oil also improves the taste, flavor and slipperiness of the product by reducing bulkiness of starchy food in mixture.

4. Conclusion

The results from analysis revealed great potential in the uses of OFSP to combat VAD and would reduce vitamin A deficiency among the most vulnerable especially infant, young children and adults who consume products from OFSP. The sensory evaluation results showed that the commercial brand used in this study was more preferred, however the study complementary food blends are still acceptable and superior in some nutritional qualities compared to the commercial brand. The study shows that an acceptable and nutrient dense complementary food could be produced from the combination of orange fleshed sweet potato, soybean, and sorghum.

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References

1. Onabanjo OO, Oguntona CRB, Maziya-Dixon B, Olayiwola IO, Oguntona EB, Dixon AGO. Nutritional Evaluation of four Optimized Cassava-Based Complementary Foods. *Afr J. Fd Sci, 2,* 2008,136 – 142.
2. Igyor MA, Yusufu PA, Sengev IA. Evaluation of physicochemical, functional and sensory properties of fermented fura powder supplemented with soy. *Nig Fd J., 28*(2), 2010, 454 – 462.
3. Omueti O, Oguntona EB, Jaiyeola O, Ashaye OA. Nutritional evaluation of home-prepared soy-corn milk – A Protein Beverage. *Nutrition and Food Science, 30*(3), 2000, 128 – 132.
4. Klemm RDW, West-Jr KP, Palmer AC, Johnson Q, Randall P, Ranum P, Northrop-Clewes, C. Vitamin A fortification of wheat flour: considerations current recommendations. *Food and Nutr, 31*(1), 2000, S47 – S61.
5. Martin H, Laswai H, Kulwa K. Nutrient content and acceptability of soybean based

complementary food. *Afr J. Fd, Agric, Nutr and Dev, 10*(1), 2010, 1684 – 5358.
6. Future harvest. *Preventing childhood blindness in Africa with sweet potato root crops on a mission to remote areas*, 2004.
7. Mayo-Wilson E, Imdad A, Hefzer K, Yakoob MN, Bhtta ZA. Vitamin A supplements for preventing mortality, illness, and blindness in children aged under 5: Systematic review and meta-analysis. *British Med J., 342*, 2011, d5094.
8. Tumwegamire S, Kapinga R, Zhang D, Crisnam C, Angili S. Opportunities for promoting orange fleshed sweet potato among food-based approach to combat vitamin A deficiency in sub-saharan. *Afr J. Afr Crop Sc, 12*(3), 2004, 241 – 253.
9. Jaarsveld C, Johnson L, Carnell S, Liewellyn CH. Beta-carotene rich orange fleshed sweet potato improves the vitamin A status of primary school children assessed with the modified relative dose response test. *Amer J. Clinical Nutr, 37*, 2005, 121 – 134.
10. Low JW, Arimond M, Osman N, Cunguara B, Zano F, Tschirley D. Food based approach introducing orange fleshed sweet potato increased vitamin A intake and serum retinol concentrations in young children in rural Mozambique. *J. Nutr*, *135*(5), 2007, 1320 – 1327.
11. FAO/WHO. Human vitamins and mineral requirements. *Report of a joint FAO/WHO expert consultation on zinc*. FAO Food and Nutrition paper 56, 2002, FAO/WHO, Rome, Italy.
12. AOAC. *Official Methods of Analysis*. Association of Analytical Chemists. Washington D. C. USA, 2005.
13. Dubois, M, Gilles KA, Hamilton JK, Rebers PA, Smith F. Colorimetric method for determination of sugars and related substances. *Analy Chem, 28*, 1956, 350 – 356.
14. WHO/UNICEF. *Weaning from breast milk to family food*. A guide for health and community workers. Geneva, World Health Organization, 1988.
15. Wondimu A, Malleshi NG. Development of weaning foods based on malted, popped, and roller- dried barley and chicken pea. *Fd and Nutr Bull,* 2(7), 1996, 169-176.
16. Okezie BO, Bello AB. Physicochemical and Functional Properties of Winged Bean Flour and Isolate Compare with any Isolate. *J. Fd Sci*, *53*, 1988, 450 – 454.
17. Kulkarni KD, Kulkani DN, Ingle UM. Sorghum in Malt-Based Weaning Food Formulation; Preparation, Functional, Properties and Nutritive Value. *Fd Nutr Bull*, *13*(4), 1991, 322 - 327.
18. Beuchat CR. Functional and electrophoretic characteristics of succinylated peanut flour protein. *J. Agric Fd Chem*, *25*, 1977, 258 – 261.
19. Sosulski FN. The centrifugal method for determining flour absorptivity in hard red spring wheat. *Cer Chem, 39*, 1962, 344 – 346.
20. Leach HW, McCowen LD, Schoch TJ. Structure of the starch granules I: Swelling and solubility patterns of various starches. *Cer Chem*, *36*, 1959, 534 – 541.
21. Iwe MO. *Handbook on sensory methods and analysis*. Enugu, Rojoint communications services limited, 2002.
22. Zakpaa HD, Mak-Mensah EE, Adubofour J. Production and characterization of four produced from ripe "apem" plantain (Musa sapientum L. var. paradisiacal; French horn) grown in Ghana. *J. Agric Biotec and Sust Dev*, *2*(6), 2010, 92 – 99.
23. Anigo KM, Ameh DA, Ibrahim S, Danbauchi SK. Nutrient composition of commonly used complementary foods in North Western Nigeria. *Afr J. Biotec*, *8*(18), 2009, 4211 – 4216.
24. FAO/WHO. *Food standards programme Codex Alimentarious Commission*. Foods for special dietary uses (including infants and children), 1994.
25. FAO/WHO/UNU. *Energy and Protein Requirements*. FAO/WHO Nutrition Meetings, Report Series 724. Geneva, Food and Agriculture Organization / World Health Organization, 1985.
26. Zlotkin S, Siekmann J, Lartey A, Yang Z. The role of the Codex Alimentarius process in support of new products to enhance the nutritional health of infants and young children. MIYCN SUPPLEMENT: Programs and policies to improve maternal, infant and young children. *Fd Nutr Bull*, *31*(2), 2010, S97 – S206.
27. Padmashree TS, Vijayakshami L, Puttaraj S. Effect of traditional processing on the functional properties of cowpea. *J. Fd Sci Tech, 24*, 1987, 221 – 225.
28. Agbon CA, Oguntona CRB, Mayaki TF. Micronutrient content of traditional complementary foods. *The forum for family and consumer issues, 14*(2), 2009, http://ncsu.edu/ffci/publications/2009/v14-n2-2009-summer/index. Accessed 3rd November, 2013.
29. Dewey KG, Brown KH. Update on technical issues concerning complementary feeding of young children in developing countries and implications for intervention programs. *Fd Nutr Bull*, *24*(1), 2003, 5 – 28.

30. Nnam NM. Evaluation of the effect of sprouting on the viscosity, proximate composition and mineral content of hungry rice, acha *(Digitaria exilis*) flours. *Nig Fd J.*, *18*, 2000, 57 – 62.
31. Riaz-Mian N, Swanmylingappa B. Chemical, functional, and nutritional characteristics of weaning food formulation. In Souvenir, *41st National Conference of Nutrition Society of India on chronic diseases*. The new pre-endemic, National Institute of Nutrition Hyderedal, 2006, 96pp.
32. Wadud S, Abid H, Ara H, Rosar S, Shah WH. Production, quality evaluation and storage stability of vegetable protein – based foods. *J. Fd Chem*, *85*, 2004, 175–179.
33. Ezeocha VC, Onwuka GI. Effect of processing methods on the physic-chemical and nutritional quality of maize and soybean based complementary blends. *Nig Fd J.*, *28*(2), 2010, 210 – 216.
34. Greta C, Sheghah S. Development acceptability and nutritional value of weaning mixture. *Plant Fds Hum Nutr, 41*, 2010, 107 – 116.
35. Prinyawiwatkul W, McWatters KH, Beuchat R, Egum BO. Functional characteristics of cowpea (*Vigna unguiculata*) flour and starch as affected by soaking, boiling and fungal fermentation before milling. *Fd Chem*, *58*, 1997, 361 – 372.
36. Singh J, Singh N, Sharma TR, Saxena SK. Physicochemical, rheology and cookie-making properties of corn and potato flours. *J. Fd Chem., 83*, 2003, 387-393.
37. Adebowale AA, Sanni LO, Awonorin SO. Effect of texture modifier on the physicochemical and sensory properties of dried fufu. *Fd Sci Tech Internat*, *11*(5), 2005, 373 – 382.
38. Obatolu VA, Cole AH. Functional property of complementary blends of soya bean and cowpea with malted or unmalted maize. *J. Fd Chem*, *70*, 2000, 147–153.
39. Walker AF, Pavitt S. Energy density of third world weaning foods. *Nutr Bull. 14*(2), 2007, 88–101.

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