academicJournals

Vol. 8(7), pp. 361-367, July 2014
DOI: 10.5897/AJFS2014.1173
Article Number: 0A6EB0E46536
ISSN 1996-0794

http://www.academicjournals.org/AJFS

African Journal of Food Science

Full Length Research Paper

Chemical and functional properties of complementary food blends from malted and unmalted acha *(Digitaria exilis*), soybean *(Glycine max)* and defatted sesame (*Sesamun indicum L*.) flours

IKUJENLOLA A. Victor

Department of Food Science and Technology, Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria.

Received 8 May, 2014; Accepted 25 July, 2014

Complementary foods of high nutrient qualities are expected to be given to infants in order to maintain their healthy status as they gradually transit from breastfeeding to family food. This study was aimed at producing high quality complementary food from locally available crops. Acha (*Digitaria exilis*), soybean (*Glycine max*) and sesame (*Sesamun indicum* L.) seeds were cleaned separately of dirt and extraneous materials. The acha grains were malted by steeping, germinating (72 h), drying (60°C, 20 h), desprouting, dehulling, milling and sieving. Soybean was soaked, dehulled, boiled, dried and milled while sesame seeds were soaked, acetic acid treated, rinsed, dehulled, dried, defatted, re-dried and milled. Complementary food blends were formulated at various ratios from malted and unmalted acha, full fat soybean and defatted sesame flours. The formulations produced were assessed for chemical composition and functional properties. The results showed that protein of the malted blends ranged from 7.68 – 21.68%, the energy ranged between 358.45- 433.30 kcal. The bulk density, water absorption and swelling capacities were lower in the malted blends. The viscosity of malted blends (< 2,550 Cps) was significantly lower ($p<0.05$) by LSD test than the values for unmalted blends (> 6,000 Cps). The supplementation with both soybean and sesame flours increased the protein, fat and ash contents of the blends while malting improved the consistency of the diet. The malted blends formed free flowing gruels which will aid consumption in infants.

Key words: Infants, malting, milling, protein, viscosity, water absorption.

INTRODUCTION

The use of traditional staples such as cereal as a source of complementary food for infants that are weaned from breast milk is well recognized (Fashakin and Ogunsola, 1982; Gopaldas et al., 1988; Onofioko and Nnanyelugo,

*Corresponding author. E-mail: biodunjenlola@yahoo.com, avjenlola@oauife.edu.ng. Tel: +2348033843674.

1998; Ikujenlola, 2004). However, there is an inherent problem associated with the utilization of these staple foods as complementary food and this lies in the inability of the staples to satisfactorily supply all the necessary nutritional requirements of the fast growing infants. Plant proteins are regarded as incomplete proteins because it is deficient in one or two essential amino acids. Such limiting amino acids are required for optimum growth and healthy living. Cereals like maize, wheat, barley, acha (hungry rice), millet and sorghum lack lysine as the first limiting amino acid and in some cases tryptophan as the second limiting amino acids. These essential amino acids cannot be synthesized at reasonable quantity by the body (Bressani and Elias, 1974; FAO, 1992).

In addition to the problem of essential nutrients there are also the problems of bulkiness and processing of the traditional weaning food which often lead to leaching or depletion of protein and nutrients from the resulting gruel. Adeyemi (1989) reported that fermented maize contain less than 0.5% protein after processing to maize gruel (Ogi). Meanwhile, the problem of dietary bulk has been solved using various processing methods which include malting. Malting is controlled germination of grains during which biochemical reactions take place which leads to break down of polymers to smaller units. During the process of malting or germination an inherent enzyme is activated and this enzyme has been associated with the reduction in the high dietary bulk of malted flours. The enzyme alpha amylase which converts insoluble starch to soluble sugars, resulting in a thinning effect, is an impor-tant nutritional effect of germination (Murugkar et al., 2013; Ikujenlola et al., 2013).

Fortified nutritious commercial complementary foods are unavailable especially in the rural areas and where available, they are often too expensive and beyond the reach of most families in Nigeria. FAO/WHO/UNICEF (1971) emphasized the use of local foods formulated in the home and guided by the following principles: (i) high nutritional value to supplement breastfeeding (ii) acceptability (iii) low price (iv) use of local food items (Dewey and Brown, 2003).

Acha (*Digitaria exilis*) is in abundance in the northern part of Nigeria and scanty information is available as regards its utilization in complementary food formulations. Acha contain about 7% crude protein that is high in leucine (9.8%), methionine (5.6%) and valine (5.8%). It is believed that its methionine content is twice as high as that of egg protein (Temple and Bassa, 1991; Ballogou et al., 2013). Because of the nutritional value, Acha is highly recommended for diabetic patients by doctors (Philip and Itodo, 2006). Acha like other cereal lacks lysine.

The proteins of soy bean and sesame are considered to be rich sources of lysine and their major deficiency lies in the sulphur containing amino-acids methionine and cysteine. The amino acids profile of legumes and oil seeds placed them as natural complements to cereal based diets.

This study was aimed at producing diets that can satisfactorily meet the need of the growing infants especially in the northern part of Nigeria where Acha, soy bean and sesame are abundant. Therefore, this study was designed to produce malted and unmalted complementary foods from blends of acha, soy and sesame flours and to assess the chemical and functional characteristics of the complementary foods.

MATERIALS AND METHODS

The acha (*D. exilis*) used was purchased from the Jos Market, Jos Nigeria. Soybean and sesame seeds were bought from Owo central market, Owo, Nigeria.

Production of malted acha flour

The method described by Marero et al. (1988) was adopted in the production of malted acha. The grains were cleaned in tap water and steeped in water (1:3) for 8 h. It was spread evenly (1.5 cm depth) in a germinating chamber for 72 h with constant watering to maintain its moisture content. The resulting green malt was dried in cabinet dryer at 60°C for 20 h, this was later desprouted, conditioned, dehulled, milled and sieved (Figure 1). The unmalted acha flour was produced according to the method reported by Obayanju and Ikujenlola (2002).

Production of soybean and sesame flours

The soybean and sesame flours were produced according to the methods of Obayanju and Ikujenlola (2002) and Kulkarni et al. (1989) respectively. Figure 1 gives the flow chart of the unit operations involved in the production of the various flours.

Formulations of the blends

The flours (malted and unmalted acha, soybean and sesame) were formulated into various blends using the following ratios shown in Table 1.

Determinations of proximate composition

The proximate compositions of the blends (protein, fat, ash, crude fibre and moisture) were determined by using the standard methods of AOAC (2004). Carbohydrate was determined by difference and energy value was determined by calculation using the relationship described by Osborne and Voogt (1978) (1 g protein, 1 g carbohydrate and 1 g fat were multiplied by factors 4, 4 and 9 kcal, respectively).

Determination of functional properties

The functional properties of the blends were assessed by determining the values of these parameters - bulk density, water absorption capacity, oil absorption capacity and viscosity.

The bulk density of each of the flours was determined by the

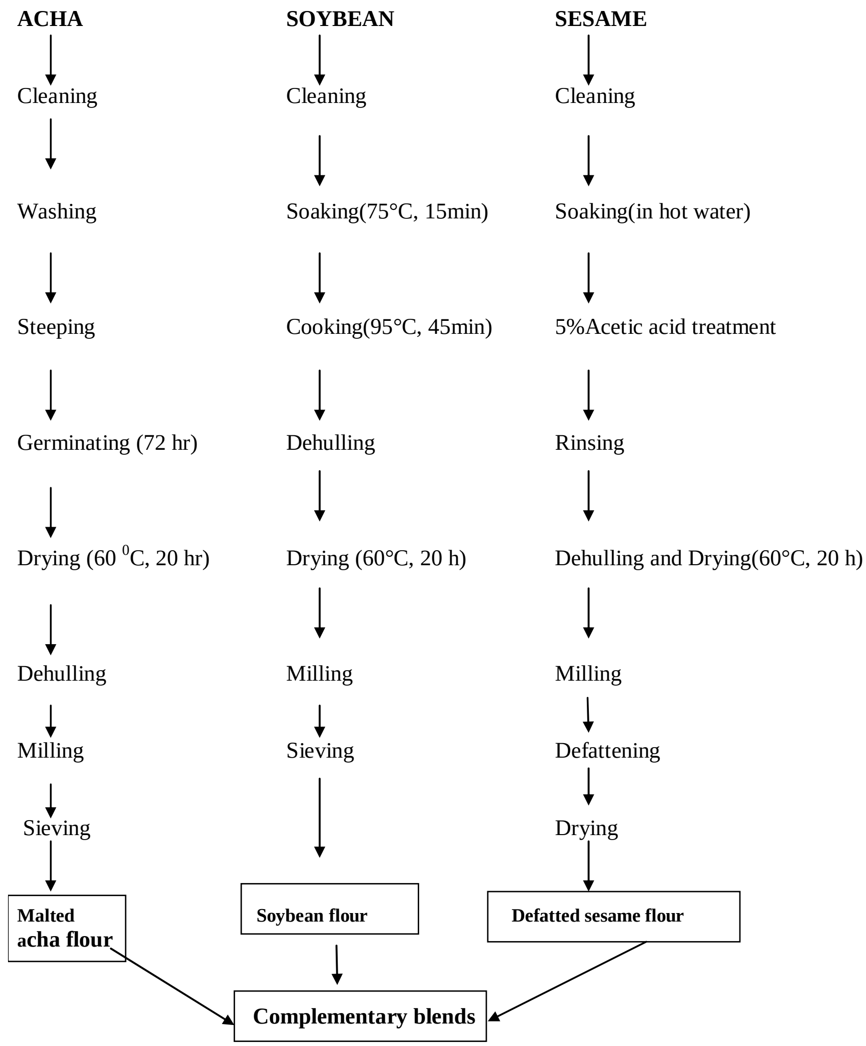

Figure 1. The production of complementary blends from acha, soybean and sesame flours.

Table 1. Various complementary blends (%).

Sample	Acha	Soybean	Sesame
Unmalted A	100	-	-
Unmalted B	70	30	-
Unmalted C	70	20	10
Malted A	100	-	-
Malted B	70	30	-
Malted C	70	20	10

method described by Okaka and Potter (1979). The water holding and oil absorption capacities were determined using the methods reported by Agrawal et al. (2013). The method described by Ikujenlola and Fashakin (2005) was used in the determination of the viscosity of the blends.

Statistical analysis

The data were expressed as means of three determinations. Data were analysed at the 0.05 level for one way analysis of variance (ANOVA) test. The level of significance test was determined using

Table 2. Proximate composition of the blends (%).

Sample	Fat	Protein	Ash	Crude fibre	Moisture	Carbohydrate	Energy (kcal)
Malted A	3.45[e]	7.68[d]	3.45[b]	2.75[c]	8.50[b]	74.17[a]	358.45[e]
Malted B	13.15[c]	16.23[b]	4.10[a]	2.20[c]	7.65[b]	56.67[c]	409.95[c]
Malted C	18.10[a]	21.68[a]	4.00[a]	2.05[c]	8.25[b]	45.92[e]	433.30[a]
Unmalted A	3.95[e]	7.23[d]	4.25[a]	2.50[c]	9.00[a]	73.07[a]	356.75[e]
Unmalted B	12.20[c]	13.25[c]	3.90[ab]	2.15[c]	8.75[ab]	59.75[c]	401.80[d]
Unmalted C	15.35[b]	17.90[b]	4.20[a]	3.50[b]	7.50[b]	51.55[d]	415.95[b]
Commercial diet -control	9.00[d]	16.00[b]	2.00[c]	5.00[a]	4.00[c]	64.00[b]	401.00[d]

Means of the same column followed by different letters are significant ($p < 0.05$) by LSD test.

the Fisher's least significance difference (LSD) test and Duncan's multiple range test using SAS program (SAS Institute Inc., Cary NC, USA 2002-2003).

RESULTS AND DISCUSSION

Chemical compositions of the complementary blends

The chemical compositions of the formulated blends are presented in Table 2. The major nutrients of the blends are protein, fat and carbohydrate. The protein content of the products ranged between 7.23 and 21.08%. The protein contents of unmalted and malted acha were 7.23 and 7.68%, respectively. The addition of soy bean and sesame flour to both unmalted and malted acha led to increase in the protein content of the products. For malted complementary blends, the protein ranged between 16.23 - 21.08% while it was 13.25 - 17.90% for unmalted complementary blends. The protein content compared favourably with the results of Omeire (2013) and Olapade and Aworh (2012) who produced diets from acha with boiled soy and coconut; and extruded acha with cowpea respectively. Legume and oil seeds contain protein of high essential amino acids (Iwe, 2003; Kaga et al., 2002; Robellen et al., 1989). Babies and growing children require protein of high quality in order to prevent the occurrence of protein malnutrition which is responsible for stunting growth.

The fat content of the malted blends ranged between 3.45 and 18.10% while the unmalted blends ranged between 3.85 and 15.35%. The addition of both soy and sesame increased the level of fat in blends. These values were higher than the values reported by Anigo et al. (2010) for blends of guinea corn, soybean and groundnut. Flours of high fat content supply higher energy value. However, food containing high fat is susceptible to both hydrolytic and oxidative/enzymatic rancidity which are responsible for off flavour. This affects both the general acceptability and storage stability of the products. Due to the high fat content of some the products, it should be used shortly after production in order to prevent deterioration as a result of ranscidity.

The ash content of the blends ranged from 3.34 - 4.10% (malted blends) and 3.90 - 4.25% (unmalted blends). The ash content of the products is higher than the 2% ash of the control. This range is higher than the ash content of fermented popcorn-African locust bean-bambara groundnut blends (FPAB) (0.85±0.01 g/100 g) but lower than 6.07±1.24 g/100 g for fermented popcorn-African locust bean blends (FPA) reported by Ijarotimi and Keshinro (2013). The ash content is directly related to the mineral composition of the blends. The crude fibre of the blends ranged from 2.05-3.50% for the all the products. These values were lower than that of the control (5.00%) but higher than the fibre of maize gruel 'Ogi' (0.85%) reported by Ijarotimi and Keshinro (2013). World Health Organization recommends crude fibre below 5% for infants (FAO/WHO, 1991). The carbohydrate ranged between 45.92 - 74.17%. The carbohydrate content of the malted blends was lower than the unmalted samples. The energy content of the products ranged from 358.45 - 433.30 kcal (malted) and 356.75 - 415.95 kcal (unmalted). These values compared favourably with that of the control (401.00 kcal). FAO/WHO (1991) recommends a range of 400 - 435 kcal/100 g. Adequate energy is required for optimum development and growth of infants; this will promote normal growth and prevent energy malnutrition. The moisture content of malted and unmalted formulated diets were below 10%. The recommended moisture content for infant food according to FAO/WHO (1991) is less than 5%. These results compared favourably with the commercial weaning food sold in Nigeria and the results agree with the earlier reports of Obatolu and Cole (2000) and Ajanaku et al. (2012) who worked on similar complementary foods.

Functional properties of the formulated diets

The bulk densities of the malted and unmalted samples

Table 3. Functional properties of complementary blends.

Sample	Malted A	Malted B	Malted C	Unmalted A	Unmalted B	Unmalted C	Commercial diet-Control
Bulk density (g/ml)	0.65	0.50	0.51	0.75	0.70	0.65	0.60
Water absorption capacity (%)	110.00	115.00	113.00	125.00	125.00	150.00	140.00
Swelling capacity (%)	115.00	110.00	120.00	130.00	145.00	165.00	145.00
Oil absorption capacity (%)	135.00	130.00	135.00	120.00	120.00	125.00	130.00

are presented in Table 3. The bulk densities ranged between 0.51 and 0.75 g/ml. The lowest value (0.51 g/ml) was recorded for the malted sample while the highest value (0.75 g/ml) was recorded for the unmalted sample. The bulk density of the control (commercial diet) was 0.60 g/ml. According to Ikujenlola and Fashakin (2005) and Onesmo (2011) malting promotes development of hydrolytic enzymes with high activity; modifies endosperm and converts stored starch to dextrin and simple sugars. Desikarchar (1980) reported that malting process is useful in the preparation of low bulk weaning foods. Low bulk density food is desired where packaging is a serious problem.

Water absorption capacities of the samples ranged between 110.00-115.00% (malted) and 125.00 - 150.00% (unmalted) and swelling capacities ranged between 110.00 -115.00% (malted) and 130.00-165.00% (un-malted). The water absorption capacity of the control was 140.00% and the swelling capacity was 145.00%. The trend of these results agrees with the report of Agrawal et al. (2013) who worked on malted foxtail and millet.

Water absorption and swelling capacities of the malted samples were lower than the values for the unmalted samples. The water absorption capacity relate to the amount of water available for gelatinization. Malting according to the reports of Marero et al. (1988), Kulkarni et al. (1989), Mensah and Tomkins (2003) and Ikujenlola and Adurotoye (2014) lowers water absorption capacity of malted flour. Lower water absorption capacity is desirable for producing a thinner gruels or porridges for children. Gruels of low water absorption capacity will allow addition of more solid, this will invariably increase the level for increase total solid. Swelling capacity of the sample determines the ability of the sample to absorb a particular amount of water and retain same within the period under study. From this result, the process of malting led to the reduction of both water absorption and swelling capacities.

The oil absorption capacities of the sample ranged from 130.00 - 135.00% (malted) and 120.00 - 125.00% (unmalted). The oil absorption capacities (Table 3) of the malted samples were higher than the unmalted complementary blends. Germination increased the capacity of acha flour to bind oil. This observation agrees with the reports of Narayana and Narasinga (1984), Ikujenlola (2004), Agrawal et al. (2013). However, this observation is at variance with the report of Obatulo and Cole (2000).

Viscosity is the measure of the resistance of fluid to flow. Food is visco-elastic in nature. Weaning or complementary food of high viscosity is usually unaccep-table to infants, it makes feeding taskful and causes choking-/suffocation. The malted blends gave lower viscosity (<2,250 cps) than the unmalted and the control samples (>10,550cps) (Figure 2). The viscosities of malted blends were significantly lower ($p<0.05$) than those of unmalted blends. The consistencies (Table 4) of the malted blends were soft and free flowing as compared to the high viscous and thick consistency of the unmalted blends. The low hot paste viscosity of the malted samples was as a result of the activity of the amylase enzyme activated during malting which dextrinifies the starch molecule of the grain to dextrin. With low viscosity infant can easily consume as much food as possible. More solid can be added to the mixture; this will increase the nutrient density of the gruels which is highly beneficial to the infants. The reports of Desikarchar (1980), Marero et al. (1988), Kulkarni et al. (1989), Uvere et al. (2002), Sajilata et al. (2002) and Ikujenlola and Adurotoye (2014) show that malting process is valuable in reducing the viscosity of infants' gruels, increase total solid and nutrient density of such food.

Conclusion

The study successfully produced complementary foods of good chemical and functional characteristics from locally available raw materials (acha, soy and sesame). It could be concluded that malting improved the chemical composition of the products and the addition of soy and sesame further enhanced the chemical composition of the blends. Moreover, the malting reduced the viscosity and the water absorption capacity of the products which is advantageous to the infant and will make feeding easier.

Conflict of interests

The authors did not declare any conflict of interests.

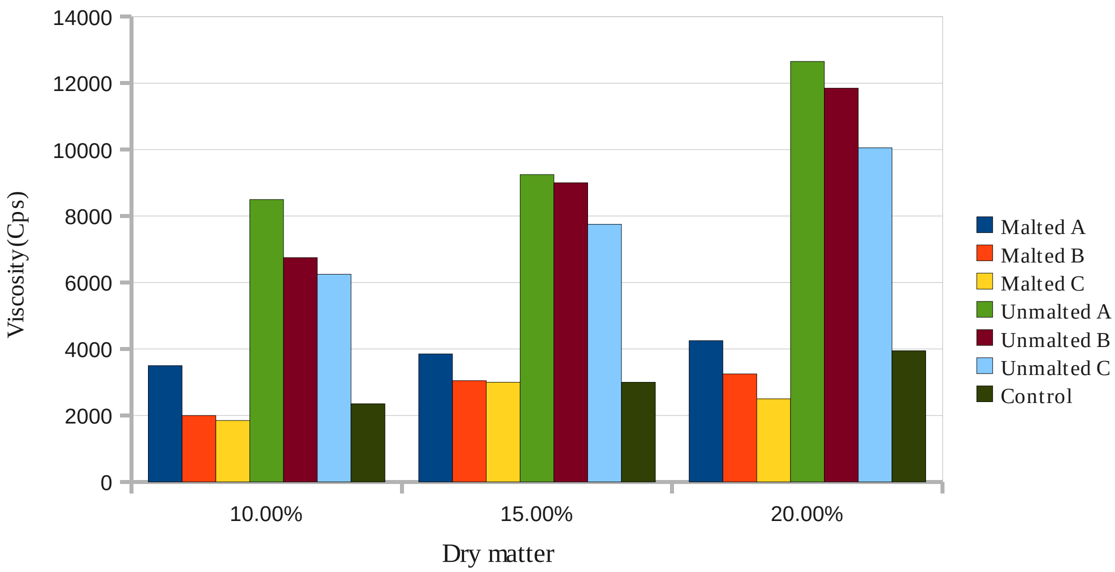

Figure 2. Viscosities of the various blends.

Table 4. Consistency of the blends.

Dry matter	Malted A	Malted B	Malted C	Unmalted A	Unmalted B	Unmalted C	Control (Nutrend)
10%	Free flowing	Free flowing	Free flowing	Free flowing	Free flowing	Free flowing	Free flowing
15%	Free flowing	Free flowing	Free flowing	Spoonful	Spoonful	Spoonful	Spoonful
20%	Free flowing	Free flowing	Free flowing	Paste like	Paste like	Paste like/ viscous	Spoonful

REFERENCES

Adeyemi AI (1989). Prospects for upgrading traditional technology for weaning food manufacture in the 1990s: In Highlights of the 18th Annual Conference NIFST: 85-94.

Agrawal D, Anubha U, Preeti SN (2013) Functional characteristics of malted flour of foxtail, barnyard and little millets. Ann. Food Sci. Technol. 14(1):44-49.

Ajanaku KO, Ajanaku CO, Edobor-Osoh A, Nwinyi OC (2012). Nutritive value of sorghum ogi fortified with Groundnut seed. Am. J. Food Technol. 7(2):82-88.

Anigo KM, Ameh DA, Ibrahim S, Danbauchi SS (2010). Nutrient composition of complementary food gruels formulated from malted cereals, soybeans and groundnut for use in North-western Nigeria. Afr. J. Food Sci. 4(3):65-72.

AOAC (2004). Official methods of Analysis. 22nd edition. Association of Official Analytical Chemists. Washington DC

Ballogou Vénérande Y, Soumanou Mohamed M, Toukourou F, Hounhouigan Joseph D (2013). Structure and Nutritional Composition of Fonio (*Digitaria exilis*) Grains : A Review. Int. Res. J. Biol. Sci. 2(1):73-79.

Bressani R, Elias LG (1974). Legume Foods In: New protein Food. Vol. 1. A Technology Academic Press .N.Y. 21-278.

Desikarchar HSR (1980). Development of weaning foods with high caloric density and low hot paste viscosity using traditional technology. Food Nutr. Bull. 2(4):21-23.

Dewey KG, Brown KH (2003). Update on Technical Issues Concerning Complementary Feeding of Young Children in Developing Countries and Implications for Intervention Programs. Food Nutr. Bull. 24:5-28.

FAO – Food Agriculture Organization (1992). Maize in Human Nutrition FAO, Rome Italy, 159-169.

FAO/WHO (1991). Protein quality evaluation. Report of Joint FAO/WHO Expert Consultation. FAO Food and Nutrition paper 51. FAO/WHO. Rome, Italy, 1991. pp.1-66.

FAO/WHO/UNICEF (1971). Protein-rich mixtures for complementary foods. Protein Advisory Group of the United Nations, PAG guidelines no. 8 New York.

Fashakin JB, Ogunsola E (1982). The utilization of local foods in formulation of weaning foods. Trop. Paediatr. (London) 28:93-96.

Gopaldas T, Mehta P, John C (1988). Bulk density reduction of traditional Indian weaning gruels. In: Athwick,D. Moes S. Schmidt, O.G eds. Improving young child feeding in Eastern and Southern Africa. Proceeding of a workshop on Household level food technology held in Nairobi, Kenya,12-16 October 1987, Ottawa: International Development research Centre. 330-339.

Ijarotimi SO, Keshinro OO (2013). Determination of Nutrient Composition and Protein Quality of Potential Complementary Foods Formulated from the Combination of Fermented Popcorn, African Locust and Bambara Groundnut Seed Flour. Pol. J. Food Nutr. Sci. 63(3):155-166.

Ikujenlola AV, Fashakin JB (2005). The Physico- chemical properties of a complementary diet prepared from vegetable proteins. J. Food Agric. Environ. 3 [3&4]:20-22.
Ikujenlola AV (2004). Quality evaluation of weaning food produced from malted cowpea and rice blend. Knowl. Rev. 8(1):83-87.
Ikujenlola AV, Adurotoye EA (2014) Evaluation of Quality Characteristics of High Nutrient Dense Complementary Food from Mixtures of Malted Quality Protein Maize (Zea mays L.) and Steamed Cowpea (Vigna unguiculata). J. Food Process Technol. 5:291.
Iwe MO (2003). The Science and Technology of Soybean: Chemistry, Nutrition, Processing and Utilization, 1st edn. Rojoint Communication Services Ltd. Enugu, Nigeria. pp. 115-146.
Kaga BI, Abdullahi SA, Dyek ND (2002). Proximate composition and Amino acid profiles of two varieties of beniseed (*Sesamun indicum*) and (*Sesamum radiatum*). J. Agric. Technol. 23:6-10.
Kulkarni KD, Kulkarni DN, Ingle UM (1989). Sorghum malt - based weaning food formulations. Preparation, functional properties, and nutritive value. Food Nutr. Bull. 13:322-327.
Marero LM, Payumo EM, Lirando EC, Larez WN, Gopez MD, Homa S (1988). Technology of weaning food formulation prepared from germinated cereals and legumes. J. Food Sci. 53:1391-1398.
Mensah P, Tomkins A (2003) Household level technologies to improve the availability and preparation of adequate and safe complementary foods. Food Nutr. Bull. 24(1):104-125.
Murugkar DA, Gulati P, Gupta C (2013). Effect of sprouting on physical properties and functional and nutritional components of multi-nutrient mixes. Int. J. Food Nutr. Sci. 2(2):8-15.
Narayana K, Narasinga Rao MS (1984). Effect of partial hydrolysis on winged bean (Psophocarpus tetragonolosus) flour. J. Food Sci. 49:944-947.
Obatolu VA, Cole AH (2000). Functional property of complementary blends of soybean and cowpea with malted and unmalted maize. Food Chem. 17:147-153.
Obayanju VS, Ikujenlola AV (2002). Formulation and Nutritional assessment of weaning food from Soybean and Acha. J. Agric. Technol. 10(2):22-27.
Okaka JC, Potter NN (1979). Physico-chemical and functional properties of cowpea flour. J. Food Sci. 44:1235-1239.
Olapade AA, Aworh OC (2012). Evaluation of extruded snacks from blends of acha (Digitaria exilis) and cowpea (Vigna unguiculata) flours. Agric. Eng. Int. CIGR Journal 14(3):210-217.
Omeire GC (2013). Physico-chemical Properties of Composite Flours from blends of Acha (Digiteria exile), Soyabean (Glycine max) and Coconut (Cocos mucifera) and their Use as Breakfast Meal. Int. J. Basic Appl. Sci. 2(3):112-117.
Onesmo NOM (2011). Effects of malting and fermentation on the composition and functionality of Sorghum flour. http://intsormil.org/smscientificpresents/2011 ZambiaWorkshop/Mella Accessed on 07th May, 2014.
Onofioko NO, Nnayelugo DO (1998). Weaning foods in west Africa. Nutritional problems, solutions. Food Nutr. Bull. 19(1):27-33.
Osborne DR, Voogt P (1978). The analysis of nutrients in Foods. London: Academic Press. pp. 239-245.
Philip T, Itodo I (2006). Acha (*Digitaria ssp*) a rediscovered indigenous crop of west Africa. CIGR EJournal 23:8.
Robellen ES, Downey KR, Kentoy OS (1989). Oil crops of the world (their breeding and utilization) Mc Graw-Hill Publishing Co. N.Y. 375-380.
Sajilata G, Singhal RS, Kulkarni PR (2002). Weaning Foods: A review of the Indian experience. Food Nutr. Bull. 23(2):208-226.
Temple VI, Bassa JD (1991). Proximate chemical composition of Acha (Digitaria exils). J. Food Sci. Agric. 58:561-564
Uvere PO, Ngoddy PO, Nnanyelugo DO (2002). Effect of amylase - rich flour (ARF) treatments on the viscosity of ferments complementary foods. Food Nutr. Bull. 23(2):190-195.