International Journal of Basic and Applied Sciences Vol. 2. No. 3. 2013. Pp. 112-117

Full Length Research Paper

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.

Omeire, G.C.

Department of Food Science and Technology, Federal University of Technology, P.M.B. 1526, Owerri, Imo State, Nigeria

Abstract

Composite flours were formulated from blends of acha (digiteria exile), soybean (Glycine max) and Coconut (Cocos mucifera) in the ratios of acha: soybean: coconut (70:20:10), (60:30:10), (40:40:20) using boiled and roasted soybean separately. Their proximate composition, functional properties, mineral, vitamin and sensory evaluation were determined. The results revealed that the moisture content of the samples were between 4% and 6 % indicating that the samples will exhibit longer shelf-life. The protein content of the samples increased with increase in the percentage of soybean in the composition. The water absorption capacity showed significant difference (p >0.05) with the samples that contained roasted soybean having higher values than the samples that contained boiled soybean. The gelation temperatures falls between (60-70)°C, which signifies that the blends can be used as quick to cook meals. The calcium, phosphorus and magnesium contents were quite high which means that their meal will support musculoskeletal system. The sensory evaluation results revealed that all the samples were generally accepted with sample that was made from acha, boiled soybean and coconut in the ratio of (60:30:10) most accepted. In conclusion, quick to cook meal especially for the elderly can be formulated from blends of acha, soybean and coconut.

Keywords: *Acha, breakfast meal, coconut, composite flour, soybean,*

Introduction

The high cost of animal protein foods especially in developing countries creates the need to combine various plant protein sources to obtain food of high protein quality. The development of foods with high levels of energy, proteins and other nutrients are necessary for complimentary food market. Cereal grains have continued to be the major basic diet of infants and adults in developing countries. Cereal provides the world with majority of its calories and half of its protein. However, most cereals are limited in essential amino acids such as threonine, lysine and tryptophan (Abiodun *et al*, 1999). Due to high lysine content of legume and their roles in complementing the limiting amino acid of cereals, they are largely replacing milk and other sources of animal protein which are expensive and are not readily available as substitute for high quality protein (Ijarotimi and Ayobami, 2006). Food legumes serve as important economic source of supplementary protein for many populations lacking animal proteins (Omeire, 2012).

Many researchers have worked extensively on cereal-legume combinations. However, Fashakin *et a*l.,(1989), observed that no single protein from the above sources was adequate to promote growth or enhance nitrogen retention as well as a milk-based diet. Acha is one of the most nutritious of all grains, but it is regarded as food for the poor. Its seed are rich in methionine and cystine. The amino acids vital to human health and which are deficient in major cereal such as wheat, rice, maize, sorghum etc. Some varieties of hungry rice can mature quickly therefore are ready to be harvested long before all other grain.

Soybean contains about 40% protein; it is higher than other legumes in protein. The protein of soybean yields all the essential amino acids in adequate amount except methionine and cystine which are deficient (Srilakshmi, 2009). Soybean is a rich source of vitamins like thiamine, riboflavin, niacin, folic acid. It is also a rich source of iron. It contains high amount of phosphorus, magnesium and potassium, and fair source of carotene and vitamin D. It is a poor source of calcium (Iwe, 2003). Soybean is nutritionally valued for their unsaturated fatty acids, protein, and fiber content. The oil contains about 85% unsaturated fatty acid and 15% saturated fatty acids. It contains 30-32% carbohydrate (soluble and insoluble). The soluble carbohydrate includes sucrose and oligosaccharide, starchynose and raffinose. Soybean is rich in lecithin and linoleic acid (Srilakshmi, 2009).

Coconut has dietary and therapeutic properties which depends on its mineral content especially, magnesium, calcium and phosphorus (Pamplona- Roger, 2004). Magnesium contributes to bone hardness and healthy cartilage in the joints. Lack of magnesium in the muscles results to cramps and nervous excitement. A food that provides these minerals in proper proportion will contribute to healthy bones, joints and muscles, all of which make up the musculoskeletal system. Although, the fatty acids that make up coconut fat are saturated, they are short and medium chain that does not promote cholesterol production in the body in contrast to the long chain saturated fatty acids from animal sources. Additionally, the coconut‘s fatty acids are absorbed and

assimilated quite well (Pamplona- Roger, 2004). Hence the incorporation of coconut into the flours. This research is aimed at finding out the physico-chemical and sensory properties of the blends.

Materials and Methods

The raw materials used were acha grains obtained from Jos, Plateau State Nigeria, soybean and Coconut from Umuahia main market in Abia State Nigeria. The acha grains were cleaned and washed several times with water. After washing, they were sun dried for 12 hours, oven dried for 30mins at 65^{o}C and milled with hammer mill to a fine texture. The flour was sieved with 75 μ mesh to obtain fine flour and stored in an air tight container. The soybean seeds were cleaned, soaked for 12 hours, dehulled and divided into two parts. One part was sundried, roasted, and milled into flour and sieved with 75 μ mesh. The second part was boiled for 30mins at 100^{o}C, drained and oven dried for 12 hours at 65^{o}C, milled and sieved with 75 μ mesh to fine flour. The coconuts were separated from their shells, washed and grated, soaked in hexane for 24h, then washed severally in hot water (60^{o}C) and placed in the sun to dry for 12h, then milled and sieved with 75 μ mesh to fine flour.

Composite flour was formulated from the processed flours (Acha, Soybean and Coconut) in the following ratios:
Sample A - Acha, Roasted Soybean, Coconut (70:20:10)
Sample B – Acha, Boiled soybean, Coconut (70:20:10)
Sample C – Acha, Roasted soybean, Coconut (60:30:10)
Sample D– Acha, Boiled soybean, Coconut (60:30:10)
Sample E – Acha, Roasted soybean, Coconut (40:40:20)
Sample F– Acha, Boiled soybean, Coconut (40:40:20).

The formulated samples were dried in hot air cabinet dryer at 120^{o}C for 10 minutes, cooled and packaged in air tight containers until analysis commenced.

Proximate analysis

Moisture content, crude fiber and ash were determined according to the methods outlined by the Association of Official Analytical Chemists (A.O.A.C, 1990), crude protein by Kjeldhal method, ether extract by solvent extraction method, carbohydrate content was by difference.

Mineral determination

Potassium and sodium were determined using the flame photometry method; phosphorus was determined by Vanadomolbdatte (yellow) spectrometry described by James (1995) while the calcium and magnesium were determined by the Versanale- EDTA complexometric titration method of James (1995).

Vitamin Determination

Vitamin C content was determined by titration method using the 2, 6- dichlorophenol indophenols method of AOAC (1990). Vitamin B1, B2 and niacin were determined by the method described by Advance biological Research (2009), while vitamin A was determined by method of AOAC (1990).

Functional properties determination

The methods described by Onwuka (2005) were used to determine the bulk density, water absorption capacity, gelation capacity, wetability pH, gelation temperature.

Sensory Analysis

The samples were used to prepare gruels and the sensory parameters (colour, texture, taste, consistency and overall acceptability) were evaluated using 25 semi trained panelist. A nine point hedonic scale was used to determine preferences of panelist ranging from (1- extremely dislike to 9-extremely like).

Statistical Analysis

Data obtained from the chemical, functional and sensory analyses were recorded in triplicate and subjected to statistical analysis of variance (ANOVA) with the mean value separate by Duncan's multiple range test at 5% level of significance.

Results and Discussion

Proximate analysis results

The results of the proximate analysis of the samples were shown in Table.1. The control had the lowest moisture value (2.5%) and the samples moisture values ranged from 4 - 6%. Moisture content of the samples were within the recommended moisture content for complementary foods by Codex Alimentarius, (1989) which should not exceed 8%. The low moisture content values may be attributed to the drying process the samples were subjected to during processing. The lower the moisture contents of a product the longer the shelf life (Nnam, 2002), which implies that the samples had good storage property, quality preservation and good resistance to microorganisms.

There were significant differences (P<0.05) between the samples and the control in terms of ash content. The ash content of the samples ranged from 2 - 6 % and the control had 3.3%. This indicated that the mineral content of these samples were high. In terms of crude protein, there was no significant difference (P>0.05) between sample F and the control. But there were significant differences (P<0.05) between the control and the other samples. Their values ranged from 4:33 - 13.97%. The results also indicated that crude protein were higher in the samples that contained the largest quantity (40%) of soybean, that is sample E (40% acha, 40% roasted soybean and 20% coconut) and F (40% acha, 40% boiled soybean and 20% coconut), their crude protein value met the Recommended Dietary Allowance recommended for babies (Guthrime, 1989).

In the fat content, there were significant difference (P<0.05) between the samples and the control. There was no significant difference (P>0.05) between samples D (60% acha, 30% boiled soybean and 10% coconut) and F (40% acha, 40% boiled soybean and 20% coconut) but there were significant differences (P<0.05) between them and the rest of the samples. The low fat content of the sample may be attributed to the fact that the coconut flour was defatted which suggested that the main source of fat in the samples was soybean.

For the fiber content there were significant difference (P>0.05) between the samples and the control. The result followed suit for carbohydrate. The fiber content of the samples was higher than the content of the control. This could be attributed to the addition of coconut and acha.

Table 1: Proximate composition of sample

Samples	Moisture %	Ash %	Protein %	Fat %	Fiber %	CHO%	Food Energy KJ
Sample A	4.00^{b}	6.00 ^{a}	4.33 ^{f}	2.00^{e}	4.00^{b}	83.67^{b}	1570.00^{e}
Sample B	4.00^{b}	4.00^{b}	8.34^{d}	4.00^{d}	4.00^{b}	87.66^{a}	1780.66^{b}
Sample C	4.00^{b}	6.00^{a}	6.52^{e}	6.00^{c}	6.00^{a}	87.48^{a}	1820.00^{a}
Sample D	6.00^{a}	2.00^{d}	10.90^{c}	8.00^{b}	6.00^{a}	73.10^{c}	1724.00^{cd}
Sample E	4.00^{b}	2.00^{d}	13.97^{b}	6.00^{c}	4.00^{b}	74.03^{c}	1718.00^{d}
Sample F	4.00^{b}	6.00^{a}	15.42^{a}	8.00^{b}	4.00^{b}	66.28^{d}	1720.00^{d}
Control	2.50^{c}	3.30^{c}	15.00^{a}	9.00^{a}	2.00^{c}	68.20^{d}	1730.00^{c}
LSD	0.65	0.60	0.14	0.37	0.69	2.51	9.63

Values in the same column having the same superscript are not significant difference (P>0.05).

Samples: Code
Sample A = Acha, Roasted soybean and coconut (70:20:10) ratio
Sample B = Acha, Boiled soybean and coconut (70:20:10) ratio
Sample C = Acha, Roasted soybean and coconut (60:30:10) ratio
Sample D= Acha, Boiled soybean and coconut (60:30:10) ratio
Sample E =Acha, Roasted soybean and coconut (40:30:10) ratio
Sample F = Acha, Boiled soybean and coconut (40: 30:10) ratio
Control = commercial breakfast cereal

Vitamin composition of the samples
The vitamin A content of the samples were significantly different (P<0.05) from each other (Table 4). Sample D (60% acha, 30% boiled soybean and 10% coconut) and F (40% acha, 40% boiled soybean and 20% coconut) had higher vitamin A content with values of 1080mg and 1620mg respectively than the control (1033mg). The rest of the samples were lower than the control. Vitamin A is very essential for growth, reproduction, good vision, healthy skin, hair and nail and to balance energy level in the human body. The deficiency of vitamin A in the body causes keratomalacia (night blindness) (Ojimelukwe et al, 2005).

There was no significant difference (P>0.05) between samples A (70% acha, 20% roasted soybean, and 10% coconut) and the control in terms of Vitamin C. There were significant difference (P<0.05) between them and the rest of the samples. There was also no significant difference between (P>0.05) sample D (60% acha, 30% boiled soybean and 10% coconut) and F (40% acha, 40% boiled soybean and 20% coconut) but there was significant difference (P<0.05) between them and the rest of the samples. Vitamin C requirement for infants is between 40mg to 50mg (Bowman and Russell, 2001). Most of the sample values were above the recommended nutrient requirement for infants. Vitamin C is required by the body for maintenance of health, gum, healing of wound, mopping excess oxygen from the system and is a powerful anti oxidant. Deficiency of vitamin C in the body will cause sore gum and scurvy (Ojimelukwe et al, 2005).

In terms of vitamin B_1 (thiamine) there was no significant (P>0.05) between sample F (40% acha, 40% boiled soybean and 20% coconut) and the control but there were significant difference (P<0.05) between the control and the rest of the samples. There was no significant difference (P>0.05) that existed among samples C (60% acha, 30% roasted soybean and 10% coconut), D (60%

acha, 30% boiled soybean and 10% coconut) and E (40% acha, 40% roasted soybean and 20% coconut) but there were significant difference (P<0.05) between them and the rest of the samples. Sample F (40% acha, 40% boiled soybean and 20% coconut) and the control had the highest values of 0.80mg while sample A (70% acha, 20% roasted soybean, and 10% coconut) had the lowest values 0.31mg. The vitamin B_1, contents of the samples were higher than the 0.3mg Recommended Dietary Allowance as (Bowman and Russel 2001), recommended for babies. The high values of vitamin B_1 in the samples was attributed to the soybean in the samples. The USDA (2009) showed that soybean has high vitamin B_1, content.

The results showed that there were no significant difference (P>0.05) between sample A (70% acha, 20% roasted soybean, and 10% coconut) and the control but there were significant difference (P<0.05) between the control and the rest of the samples in terms of Vitamin B_2. The vitamin B_2 (Riboflavin) content of the samples were between the range of 0.4 to 0.6mg. Recommended Dietary Allowance for infants is 0.3-0.4mg (Bowman and Russel 2001).
In terms of Niacin content, except samples A and B other samples met the recommended Dietary requirement and there were significant differences (P<0.05) between the samples and the control.

Table 2: Vitamins composition of the samples

Samples	Vitamin A (mg)	Vitamin C (mg)	Vitamin B_1 (mg)	Vitamin B_2 (mg)	Niacin (mg)
Sample A	270.00^{g}	35.20^{d}	0.31^{f}	0.25^{b}	1.00^{d}
Sample B	926.00^{d}	52.86^{b}	0.49^{c}	0.56^{a}	1.40^{d}
Sample C	675.00^{f}	48.40^{c}	0.63^{b}	0.49^{a}	2.60^{c}
Sample D	1080.00^{b}	66.00^{a}	0.71^{b}	0.52^{a}	3.10^{bc}
Sample E	810.00^{e}	47.50^{c}	0.68^{b}	0.45^{a}	2.90^{bc}
Sample F	1620.00^{a}	66.10^{a}	0.80^{a}	0.48^{a}	3.24^{b}
Control	1033.00^{c}	35.00^{d}	0.80^{a}	0.30^{b}	4.00^{a}
LSD	5.84	2.46	0.10	0.13	0.50

Values in the same column having the same superscript are not significantly different (P>0.05).
Samples: Code
Sample A = Acha, Roasted soybean and coconut (70:20:10) ratio
Sample B = Acha, Boiled soybean and coconut (70:20:10) ratio
Sample C = Acha, Roasted soybean and coconut (60:30:10) ratio
Sample D= Acha, Boiled soybean and coconut (60:30:10) ratio
Sample E =Acha, Roasted soybean and coconut (40:30:10) ratio
Sample F = Acha, Boiled soybean and coconut (40: 30:10) ratio
Control = commercial breakfast cereal

Mineral Composition of Samples
There were significant difference (P<0.05) between the calcium content of the samples and the control (Table 3). There were also significant difference (P<0.05) among the samples. The value of calcium in the control (540mg/100g) was higher than the value in other samples. However samples C (60% acha, 30% roasted soybean and 10% coconut) and E (40% acha, 40% roasted soybean and 20% coconut) had comparable values of these calcium 420mg and 500mg/100g respectively. The difference may be attributed to the milk added to the control which has high calcium content.

In terms of magnesium content, there were significant difference (P<0.05) between the samples. The control value was not available. The magnesium content of the formulated samples ranges from 100 to 220mg/100g. These values were higher than the 50 to 70mg/100g recommended by as nutrient requirement for babies (Bowman and Russell, 2001).

Table 3: Mineral compositions of samples

Samples	Calcium mg/100g	Magnesium mg/100g	Phosphorus mg/100g	Potassium mg/100g	Sodium mg/100g
Sample A	340.30^{d}	140.60^{d}	127.20^{d}	137.00^{e}	104.00^{e}
Sample B	140.70^{g}	100.10^{e}	110.60^{f}	142.00^{e}	104.00^{e}
Sample C	420.20^{c}	200.40^{b}	129.90^{d}	147.00^{de}	121.00^{d}
Sample D	180.00^{f}	140.70^{d}	116.10^{e}	158.00^{d}	121.00^{d}
Sample E	500.10^{b}	220.00^{a}	163.10^{b}	188.00^{c}	139.00^{c}
Sample F	250.00^{e}	180.50^{c}	143.80^{c}	234.00^{b}	174.00^{a}
Control	540.00^{a}	NA	430.00^{a}	650.00^{a}	170.00^{b}
LSD	2.87	3.09	5.48	12.07	2.12

Values are means of data of triplicate determinations. Values in the same column having the same superscript are not significantly different (P>0.05).

Samples: Code

Sample A = Acha, Roasted soybean and coconut (70:20:10) ratio
Sample B = Acha, Boiled soybean and coconut (70:20:10) ratio
Sample C = Acha, Roasted soybean and coconut (60:30:10) ratio
Sample D= Acha, Boiled soybean and coconut (60:30:10) ratio
Sample E =Acha, Roasted soybean and coconut (40:30:10) ratio
Sample F = Acha, Boiled soybean and coconut (40: 30:10) ratio
Control = commercial breakfast cereal

NA – Not Availiable.

Functional Properties of Samples

The bulk density was lowest in the control (0.5 g/ml) than other samples. Samples A and B (70 % acha, 20% soybean and 10% coconut) had the highest value in the formulated samples with 0.69 g/ml. Bulk density of food increases with increase in starch content of the samples (Bhttachyra and Brakash, 1994). Increase in the percentage of acha resulted to increase in starch and subsequent increase in bulk density. Bulk density gives an indication of the relative volume of packaging material required. The samples generally had low bulk density. Low bulk density is also necessary in complementary feeding because it will allow the infants to take in more food, gain all the nutrients required by the infant (Onwueme, 1987).

The control had the highest value of water absorption capacity of 4mg/g than the rest of the samples. Samples A,C and E that contained roasted soybean were significantly different ($p< 0.05$) from samples B,D and F that contained boiled soybean. The result may be attributed to the level of denaturation of the proteins during processing. Water absorption capacity is important in the development of ready to eat food cereal grains, since a high water absorption capacity may assure product cohesiveness (Bhttachyra and Brakash, 1994).Water absorption capacity is an indication of the extent to which protein can be incorporated into food formulation. Increase in water absorption capacity implies high digestibility of the starch (Iwe and Egwuekwe, 2010).

There were significant differences ($p<0.05$) in the gelation capacity of the samples and the control. There were also significant differences ($p<0.05$) among the samples. Gelation is one of the most important functional properties which determine the suitability of incorporation of a particular substance in food product (Onwueme, 1987). There were significant differences between the wettability of the samples and the control. The control dissolved faster at 5s than the other which values ranges from 8.40 – 15.30secs.

Table 4: The functional properties of the samples

Sample	Bulk density (g/ml)	Water absorption Capacity (g/ml)	Gelation capacity (mins)	Wetability (sec)	pH	Gelation Temp ^{0}C
Sample A	0.69^{b}	3.50^{b}	8.00^{c}	15.30^{a}	5.98^{bc}	60.80^{cd}
Sample B	0.69^{b}	3.00^{c}	4.25^{f}	13.50^{b}	5.93^{c}	62.50^{c}
Sample C	0.67^{b}	3.50^{b}	10.15^{b}	15.15^{a}	6.10^{b}	65.00^{b}
Sample D	0.66^{b}	3.00^{c}	6.30^{d}	13.45^{b}	6.03^{bc}	66.50^{b}
Sample E	0.64^{b}	3.50^{b}	5.00^{e}	15.21^{a}	6.25^{b}	68.60^{a}
Sample F	0.65^{b}	3.00^{c}	3.30^{g}	8.40^{c}	6.16^{bc}	70.00^{a}
Control	0.50^{a}	4.00^{a}	12.36^{a}	5.00^{d}	6.60^{a}	60.00^{d}
LSD	0.10	0.33	0.54	0.24	0.27	2.01

Values in the same column having the same superscript are not significantly difference ($P>0.05$).

Samples: Code

Sample A = Acha, Roasted soybean and coconut (70:20:10) ratio
Sample B = Acha, Boiled soybean and coconut (70:20:10) ratio
Sample C = Acha, Roasted soybean and coconut (60:30:10) ratio
Sample D= Acha, Boiled soybean and coconut (60:30:10) ratio
Sample E =Acha, Roasted soybean and coconut (40:30:10) ratio
Sample F = Acha, Boiled soybean and coconut (40: 30:10) ratio
Control = commercial breakfast cereal

Sensory Evaluation of Samples

There was no significant difference between sample D (60% acha, 30% boiled soybean and 10% coconut) and the control in terms of texture but there were significant differences ($P<0.05$) between the rest of the samples. Sample D (60% acha, 30% boiled soybean and 10% coconut) and F (40% acha, 40% boiled soybean and 20% coconut) compared favorably with the control in all the sensory parameters and can be used as a complementary food for infants or as a breakfast cereal. All the samples were generally accepted based on a nine point hedonic scale, their value are higher than the mean value.

Table 5: Sensory evaluations of samples

Sample	Texture	Colour	Taste	Consistency	General acceptability
Sample A	6.27^{c}	6.27^{cd}	6.47^{b}	5.47^{d}	6.07^{cd}
Sample B	6.74^{bc}	6.60^{b}	5.80^{b}	6.60^{b}	6.54^{c}
Sample C	6.14^{c}	5.74^{d}	4.60^{c}	5.40^{d}	5.74^{d}
Sample D	8.00^{a}	7.20^{ab}	7.94^{a}	7.47^{ab}	8.00^{ab}
Sample E	6.54^{bc}	6.13^{cd}	6.20^{b}	6.67^{b}	6.40^{c}
Sample F	7.34^{b}	7.60^{a}	6.74^{b}	7.14^{bc}	7.47^{b}
Control	8.09^{a}	7.94^{a}	8.80^{a}	8.14^{a}	8.40^{a}
LSD	0.66	0.72	0.90	0.68	0.61

Values are mean data of triplicate determinations. Values in the same column having the same superscript are not significantly difference (P>0.05).

Samples: Code

Sample A = Acha, Roasted soybean and coconut (70:20:10) ratio
Sample B = Acha, Boiled soybean and coconut (70:20:10) ratio
Sample C = Acha, Roasted soybean and coconut (60:30:10) ratio
Sample D= Acha, Boiled soybean and coconut (60:30:10) ratio
Sample E =Acha, Roasted soybean and coconut (40:30:10) ratio
Sample F = Acha, Boiled soybean and coconut (40: 30:10) ratio
Control = commercial breakfast cereal

Conclusion

The study revealed that blends of flours from different ratios of acha, soybean and coconut are nutritionally adequate and posses good functional properties and therefore can be used as break fast cereals. However, the result of the sensory evaluation showed that sample D that contained 60% acha, 30% soybean and 10% coconut was most accepted and compared favourably with the control. Addition of other nutrients to the composition will go along way to produce products that can be used as infant formular.

References

Abiodun, S.I., Anthony, A.O. and Ibidapo, O. T. (1999). Biochemical composition of infant weaning Foods fabricated from fermented blends of cereal and soybean. Food Chemistry 65: 35-39.

A.O.A.C. (1990).Official Methods of Analysis. Association of Official Analytical Chemist 15th ed. Vol.2 Associate of Official Chemistry. Arlington, Virginia, U.S.A.

Bhttachyra, S. and Brakash, M. (1994). Extrusion blends of rice and chicken pea flours. A response surface analysis. J. Food Engr. 21:315-317.

Bowman, B.A. and Russell, R.M. (2001). Present knowledge in nutrition. 8th edition ILSI press Washington, DC.

Codex Alimentarius, (1989). Vol. IX, 1st edition, Rome. Food and Agriculture Organization pp 15.

Fashakin, J.B., Aweyefa, M.B. and Furst, P. (1989).The application of protein concentrates from locally available legumes in development of weaning foods. J. Nutri. Sci Frnahrungswisse, 25: 220-227.

Guthrime, A.A. (1989). Introductory Nutrition. 7th edition. Times Mirrow Mosby College publisher London pp 485-500.

Ijarotimi, O.S and Ayobami, A. O. (2006). Nutritional composition, sensory evaluation of a potential weaning diet from low cost material. Igbo Ecol nutria 8:111-112.

Iwe, M. O. (2003). The science and Technology of soybean. Rejoint communication services Ltd, Enugu. Pp 43.

Iwe, M.O. and Egwuekwe, E.I. (2010). Production and evaluation of cookies from Xanthosoma sagittifolium and Colocasia esculenta blends. Nigerian Food Journal. Vol.28:1 pp145-153.

James, C.S. (1995). Analytical Chemistry of Foods. Chapman and Hall, Glasgow, UK. Pp 46.

Nnam, N.M. (200). Evaluation of complimentary foods based on maize, groundnut pawpaw and mango flour blends. Nig. J. of Nutritional Sciences 22:8-18.

Ojimelukwe, P.C., Asumugha, V.C. and Omeire. G.C. (2005). Fundamentals of Food Science and Nutrition. Bel's Books Publisher Nigeria.

Omeire, G.C. (2012). Amino acid profile of raw and extruded blends of African yam bean (Sphenosthlis stenocarpa) and cassava flour. American Journal of Dood and Nutrition Vol2:3 65-68.

Onwueme, I.C. (1987). Strategies for increasing cocoyam (cold cassia and xanthosana spp) in Nigeria Food Basket). In Arene O.B. and O.a.(eds) Proc. 1st National Workshop on cocoyam pp 35-37. Aig NRCRI umudike Nigeria.

Onwuka, G. I. (2005).Food Analysis and Instrumentation: Theory and Practice. Naphthali Prints, Lagos.

Pamplona-Roger, G. D. (2004). Encyclopedia of foods and their healing power. Education and Health Library. Vol. 1

Srilakshmi, B. (2009). Food science. New Age International Ltd, publishers, New Delhi. Pp 88 – 90, 115.

USDA. (2009). Nutrient Database from Standards. FDA/IFIC Brochure Washington, DC