Indian J.Sci.Res.3(1) : 43-50, 2012

QUALITY EVALUATION OF SOY-ACHA MIXES FOR INFANT FEEDING

F.U. UGWUONA[a], M.D AWOGBENJA[b1] AND J.I OGARA[c]

[a]Department of Home Science & Management, Faculty of Agriculture, Nasarawa State University, Keffi., Nigeria.
E-mail: ugwuonafu@yahoo.com
[b]Department of Home Science & Management, Faculty of Agriculture, Nasarawa State University, Keffi., Nigeria.
E-mail: amdehinde@yahoo.com
[c]Department of Basic Science, College of Agriculture, Lafia, Nasarawa State, Nigeria.
E-mail: ogarajanet@yahoo.com

ABSTRACT

This work evaluated the chemical and sensory properties of Soy-acha complementary blends for infant feeding. Blanched acha flour (94-96^{0}C for 20min), blanched Soybean flours (94-96C for 20min, 30min and 40min), and fermented soybean flours (12h, 18h and 24h in 1:3 v/v cold water) were analyzed for chemical composition. The 30min blanched and 18h fermented soy flours were each blended with the acha flour in the ratio of 0:10, 1:9, 2:8, 3:7 and 4:6 proportions. Soy acha blends were analyzed for chemical and sensory properties. Fermentation and blanching affected chemical composition of soybeans. Protein contexts increased significantly (P<0.05) from 36.01 to 47.67% for 30min blanching, and to 44.26% for 24h fermentation. Carbohydrate content decreased significantly (P<0.05). Soy flour (fermented or blanched) addition increased protein, crude fiber, fat and ash contents; and improved the energy value but decreased carbohydrate contents of the blends.

KEY WORDS : Soy-acha mixes, infant feeding, quality evaluation

Complementary foods are solid foods that are gradually introduced into the infant's diet to complement the mother's breast milk which still forms the main part of the diet. They are used for gradual withdrawal of the infant from the mother's milk, and for preparing the infant for total adaptation to the regular food of the family. The period of complementary feeding is a critical phase of the infant's developmental system with respect to nutrition and digestion (WHO, 2004). Complementary foods should therefore be low bulk density, high nutrient content and be microbiologically safe.

In most developing countries, particularly in Africa and Asia, weaning foods are prepared locally from cereal grains which form part of the staple food of the people. Maize, sorghum, millet, rice and acha are the common cereal grains used in Nigeria. The grains are first steeped in cold water to ferment, then wet-milled and sieved. The sieved slurry is rested to sediment and then decanted to get the weaning food which is a white thick paste called pap or akamu. A suspension of pap is cooked with boiling water into jelly gruel for the infant. Cereal-based weaning foods of this nature are composed mainly of starch and water. They are low in protein, particularly in lysine and tryptophan (Temple and Bassa, 1991; Okoh, 1998).

Also, the paste-type complementary foods are more prone to microbiological contamination and may easily cause diarrhea. Acha (*Digitaria exillis),* a cereal grain, need to be complemented with a legume for high nutrient value for infant feeding. Soybean (*Glycine max)*, a legume, is high in protein, including the tryptophan and lysine but deficient in the sulphur containing amino acids (methionine and cystine). Unfortunately soybean has high content of anti-nutritional factors; and these have to be removed or at least reduced to fully exploit the nutritive potentials of the legume.

The purpose of this study is to evaluate the chemical composition and sensory quality of flour blends of fermented or blenched soybean with acha for infant feeding.

MATERIALS AND METHODS

Soybean seeds (*Glycine max*) and acha grains (*Digitaria exilis*) were purchased from retail stockers at Lafia main market, Nasarawa State, Nigeria. All laboratory reagents used were of analytical grade .

Processing of Soybean Seeds into Flours

Soybean seeds were cleaned and divided into 6 portions of 500g each. The first 3 portions were hot-water blenched for 20, 30 and 40 minutes respectively. They were then soaked in clean cold water for 30minutes, dehulled manually, washed, drained, sun-dried for 2 d and then oven-dried at 50^{0}C for 18h.

[1]**Corresponding author**

The remaining 3 portions were fermented for 12h, 18h and 24h respectively at room temperature in cold water (28±2^{0}C) with repeated change of water after every 4h. They were then cooked (96-98^{0}C) for 20 minutes, dehulled manually, washed, rinsed, sun-dried for 2h and oven-dried at 50^{0}C for 18h. Both the blanched and fermented soybeans were milled into flour in a hammer mill (I.G. Jurgens, Bremmer, Germany), packaged in black polythene bags and stored in air tight containers until needed.

Processing of Acha Grains into Flour

The acha grains (2000g) were washed 3 times in a clean tap water and hot-water blanched batch-wise for 20 minutes. This was drained through a basket sieve for 30 minutes and oven-dried at 50^{0}C for 18h. The grains were milled into flour in a hammer mill (I.G. Jurgen, Bremer, Germany), packaged in black polythene bags and stored in air-tight containers until needed.

Formulation of Soy-Acha Complementary Foods

Based on proximate composition, after analysis, the 30minutes blanched and 18h fermented soybean flours were chosen for the weaning food formulation. Both the 30-minutes blanched and 18h fermented soy flours had high proportion of protein, crude fat, fiber and ash (Table 2), all of which the infant needs for growth and body building. The different Soy-acha blends formulated for the weaning foods are as shown in table -1. Nutrend, a commercial infant feeding formula popular in Nigeria, will be used as a positive standard.

Table 1: Formulation of soy-acha complementary foods with blanched (30 minutes) and Fermented (18h) soybean flours

Soy-acha blend sample	30-minutes blanched Soy-bean flour(%)	20-minutes blanched acha flour (%)
AS (100%)	00	100
Sb (10%)	10	90
Sb(20%)	20	80
Sb(30%)	30	70
Sb(40%)	40	60
	18-hours fermented soybean flour	20-minutes blanched acha flour
Sf(10%)	10	90
Sf(20%)	20	80
Sf(30%)	30	70
Sf(40%)	40	60

AS=100% acha flour; sb.(10%), sb (20%), sb (30%), sb (40%) = soy-acha mixes with 10%, 20%, 30%, 40% blanched (30 min.) soybeans respectively; sf (10%), sf (20%), sf (30%), sf (40%) = soy-acha mixes with 10%, 20%, 30%, 40% fermented (18h) soybeans respectively.

Chemical analysis

Moisture, crude protein (%N × 6.25), fat, crude fiber and ash contents of flours and flour blends were determined in duplicates as described by the Official Methods (AOAC, 1990). Digestible carbohydrate was determined by difference. The energy value was calculated by using the Atwater factors with 1g protein, 1g carbohydrate and 1g fat having energy values of 4 kcal, 4 kcal and 9kcal respectively and then converted to KJ/kg

(1kcal equals 4.286KJ). The ash samples were used to determine the mineral contexts by first dissolving in distilled water to get the filtrates. The filtrates were used to determine calcium, iron and phosphorus as described by Onwuka (2005), using an atomic absorption spectrophotometer (Flame system, Buck Scientific Inc. Model 200A) and using the standard lamps.

Trained Sensory Evaluation

A 15- member panel was trained according to the spectrum methodology. The spectrum method involves scoring perceived intensities with reference to pre learned scales using standard attribute names with their standards that define scales of intensities (Mellgaard et al., 1998). Panelists underwent an orientation session using 100% acha flour (control, "as is") and flour blends with different concentrations (levels) of soy flour. The panelists used the orientation session to improve their reproducibility and accuracy of sensory assessment.

Four levels (10%, 20%, 30% and 40%) of fermented and blanched soy flour additions were compared with 100% acha flour (without soy flour addition) to determine the effect of soy addition on sensory properties of the products. Gruels (19% w/v) were prepared by mixing the flour blends and acha flour (100%) in boiling water (97^0C) and stirring continuously for 8mins. These were served warm (38^0C) to the trained panelists in the sensory evaluation laboratory. Each gruel sample was evaluated in duplicates by the panelists for colour, flavour, texture, mouth feel and overall acceptability attributes using a 9-point hedonic scale (1=dislike extremely, 2 = dislike very much, 3= dislike moderately, 4= dislike slightly, 5= neither like nor dislike, 6= like slightly, 7= like moderately, 8= like very much, 9= like extremely). Scores were collated and analyzed statistically.

Statistical analysis

Data were analyzed using the general linear model (GLM) procedure with SAS version 8.2 software package (SAS 2002 Institute Inc. Carry, M.C. USA). The average scores generated were subjected to analysis of variance and separated by LSD analysis at a least significant difference of 0.05 p value.

RESULTS AND DISCUSSION

Chemical Composition of Raw Soybean and Acha

Table- 2 shows the chemical composition of raw soybean (*Glycine max*) and acha (*Digiteria exillis)* used in this study. They had moisture contents of 10.04% for acha and 7.01% for soybean, very much below the maximum 12.5% water content for shelf-stable storage and viability of food grains (Chakraverty, 2004). Soybean had high protein (36.01%), fat (18.72%), and ash (4.5%) contents. Acha had high carbohydrate (78.35%) content but low protein (8.82%), fat (0.76%) and ash (0.20%). The fiber contents in soybean (2.36%) and acha (1.86%) is moderately sufficient for infant nutritional needs. The calcium and phosphorus contents were 18mg and 27mg per 100g soybean, 17mg and 11mg per 100g acha respectively. Traditional infant feeding formulas in Nigeria are mainly fermented cereal gruels (Inyang and Idoko, 2006), including acha and not legumes. There is the need to supplement acha with soybean to improve the nutritional value, as revealed from the proximate compositions, particularly the protein content of acha for infant feeding.

Table 2: Chemical Composition of raw soybean (*Glycine max*) and acha (*Digiteria exilli)*

	Moisture %	Crude protein %	Crude fibre %	Crude fat %	Ash %	Digestible carbohydrate %	Calcium %	Phosphorus %
Soybean	7.31±0.02	36.01±1.12	2.36±0.4	18.72±0.07	4.50±0.03	30.80±0.68	0.18±0.03	0.27±0.03
Acha								
Acha	10.04±0.84	8.82±1.33	1.86±0.02	0.76±0.02	0.20±0.00	78.35±3.42	0.17±0.01	0.11±0.01

Chemical Composition of Blanched and Fermented Soybean Flours

Fermentation and blanching significantly ($p<0.05$) affected the chemical composition of soybean flour (Table -3). Both decreased the moisture contents. The 18h fermentation decreased moisture content from 7.01% to 5.57% and the 24h fermentation to 6.38%. Also 20min blanching deceased moisture content from 7.01% to 4.48% while blanching for further 10min increased the moisture from the 4.48% back to 5.35% and for further 20 min to 5.35%. Blanching beyond 30min. and fermenting beyond 18h tend to increase the water content of the flour and should be avoided to retain the functionality and storage stability of flour (Carvalino et al., 2006; Inyang and Idoko, 2006).

Fermentation increased protein, fat, ash, calcium and phosphorus content but decreased crude fiber and digestible carbohydrate (Tables 2 and 3). However, these were not always proportional to the fermentation time. A 12h fermentation increased fat and ash contents from 18.00% and 4.50% to 19.04% and 5.17% respectively but fermenting for further 12h reduced these values to 18.58% and 4.66% respectively. Also blanching improved the protein, calcium and phosphorus but deceased digestible carbohydrate and ash contents at all instances of blanching. The fat and crude fiber contents were at variance. Hot-water blanching unlike steam-blanching is known to leach some vital nutrients out of blanched products. The effect of fermentation and blanching on protein contents of the flour was significantly ($P<0.05$) in the order: 20 and 30min blanching (47.65% & 47.67%) >24h fermentation (44.26%) >12h & 18h fermentation (42.68% & 42.44%) > 40min blanching (36.18%). The 30min blanching and 18h fermentation produced flours with the best average optimum nutritional value for dietary needs of human (National Academy of Science, 1989). Blanching and fermentation time should be optimized to improve the nutritive and functional properties of food grains.

Table 3: Chemical Composition of balance fermented soybean flours

Treatment	Moisture %	Crude protein %	Crude fiber%	Crude fat %	Ash %	Digestible carbohydrate %	Calcium %	Phosphorus%
FF(12h)	7.78±0.09	42.68±1.36	4.41±0.62	19.04 ± 0.42^{a}	5.17 ± 0.07^{a}	22.21 ± 1.80^{a}	0.43 ± 0.01^{b}	0.020±0.00
FF(18h)	5.57±0.00	42.44±1.02	14.49±1.20	19.30 ± 1.8^{a}	4.71 ± 0.06^{ab}	13.31 ± 0.41^{c}	0.30±0.00	0.28 ± 0.02^{b}
FF(24h)	$6.38^{b}\pm0.11$	44.26 ± 1.00^{b}	14.49 ± 0.14^{d}	18.58±1.10	4.66a±0.32^{b}	15.14 ± 0.80^{b}	0.38 ± 0.02^{b}	0.28 ± 0.02^{b}
BF(20min)	4.48 ± 0.13^{c}	47.63 ± 1.83^{a}	13.59 ± 0.42^{bc}	17.90 ± 1.12^{bc}	3.83 ± 0.02^{c}	12.60 ± 0.05^{c}	0.43 ± 0.00^{b}	0.33 ± 0.01^{a}
BF(30min)	$.35\pm0.06^{c}$	47.67 ± 1.90^{a}	15.49 ± 1.00^{a}	17.05 ± 0.48^{c}	4.02 ± 0.01^{c}	0.46 ± 0.21^{d}	0.05 ± 0.01^{a}	0.31 ± 0.04^{a}
BF(40min)	5.05 ± 0.03^{a}	36.18 ± 1.12^{d}	14.43 ± 0.72^{b}	19.88 ± 1.00^{a}	3.38 ± 0.01^{c}	21.11 ± 0.90^{a}	0.05±0.001	0.33 ± 0.00^{a}

FF= Fermented (for 12h, 18h and 24h) soybean flour ; BF=Blanched (for 20 min, 30 min. and 40 min.) flour
12h, 18h and 24h are various fermentation time in hours respectively,
20min, 30min and 40min are various blanching time in minutes respectively.
Values are means ± standard deviations of three determinations.

Proximate Composition and Energy Values of Soy-Acha Weaning Foods

Table 4 shows the proximate composition and energy values of soy acha flours containing 0%, 10%, 20%, 30% and 40% of 18h-fermented or 30min blanched soy flours (soybean flour). Proximate composition of nutrend, a commercial infant formula used as a positive control in this work, is also shown in table 2. Addition of fermented or blanched soy flour decreased the moisture and carbohydrate contents of samples. However the protein, crude fiber, fat and ash increased proportionally with the addition of soy flour. These trends of increases in fat and protein contents are in line with the report of Temple and Bassa (1991); that addition of legumes to cereals improves the level of protein. Protein increased from 8.82% for 0% Soy flour to 10.36% for 10% and to 22.01% for 40% fermented soy flour addition; and to 13.06% for 10% and to 22.18% for 40% blanched soy-flour addition. The range of protein contents (21 to.23%) of samples with 20% to 40% soy flour addition were significantly higher ($P<0.05$) than that (15.06%) of the control, nutrend. The 8.82% protein of the 100% acha flour was significantly ($P<0.05$) lower than those of other samples. Crude fiber increased from 0.02%, fat from 0.67% and ash from 0.20% for 0% soy-flour to 0.48% to 1.86% fiber, 2.44% to 9.45% fat, and 0.72% to 3.86% ash for 10 to 40% soy -flour addition. These increases are expected due to the complementation of acha flour with soy-flour that contain higher amount of most nutrients (Table -3). The energy values of the flour blends were very high, with 40% soybean addition having more qualitative sources but with the least value (1628.40KJ) than every other blends. The energy value of the nutrend is relatively lower (1308.83KJ) than that of any of the complementary blends. The soy-acha flours with 20 to 40% soy-flour had moisture contents (6.25% to 9.33%) significantly ($P<0.05$) higher than that of the control (4.14%moisture).

Table 4: Proximate Composition and energy value of Soy-acha weaning food

Treatment	Moisture %	Crude protein %	Crude fiber%	Crude fat %	Ash %	Digestible carbohydrate %	Energy per 100% (KJ)
Sf (10%)	9.99±0.61	10.36±0.90	0.48±0.00	2.44±0.01	0.72±0.00	86.00±1.76	1606.01
Sf (20%)	22±0.70	14.76±0.18	1.42±0.01	3.55±0.01	3.51±0.12	76.96±1.20	1671.10
Sf(30%)	9.26±0.40	21.36±0.23	1.24±0.00	7.84±0.22	3.86±0.09	67.7±0.77	1788.29
Sf(40%)	7.98±0.18	22.01±0.17	1.71±0.04	8.22±0.42	2.30±0.00	59.71±1.80	1679.60
Sb(10%)	8.80±0.22	13.06±0.01	0.97±0.04	2.99±0.00	2.47±0.00	80.51±1.20	1689.00
Sb (20%)	9.90±0.68	15.84±0.66	0.86±0.00	5.24±0.09	312±0.00	76.84±0.92	1750.92
Sb (30%)	9.78±0.50	21.77±1.00	1.34±0.00	7.48±0.00	3.45±0.01	67.96±1.83	1774.21
Sb(40%)	6.25±0.04	23.18±1.30	1.86±0.03	9.43±0.40	3.45±0.21	65.55±1.30	1628.40
AF	10.04±0.38	8.82±0.10	0.02±0.01	0.67±0.00	0.20±0.00	88.45±2.00	1655.61
Nutrend	4.14±0.04	15.06±0.02	1.08±0.01	3.81±0.13	0.19±0.02	63.70±0.32	1308.83

AS=100% acha flour; sb.(10%), sb (20%), sb (30%), sb (40%) = soy-acha mixes with 10%, 20%, 30%, 40% blanched (30 min.) soybeans respectively; sf (10%), sf (20%), sf (30%), sf (40%) = soy-acha mixes with 10%, 20%, 30%, 40% fermented (18h) soybeans respectively.
Values are Means ± Standard deviations of three determinations

In cereal legume mixed for infant feeding, it is beneficial to ensure that optimum cereal-legume ratio is used. Maximum biological benefit is obtained only when each of the components contributes about 40 to 50% of the total protein, with other nutrients relatively sufficient (Akobundu, 1992). This is as a result of the differences in amino acid pattern of cereals and legumes. Cereals are high in total sulphur-containing amino acids but deficient in lysine and tryptophan. Legumes are high in lysine and tryptophan but deficient in the sulphur-containing amino acids (Akobundu, 1992). The infants need moderate amount of carbohydrate but high contents of protein, water, fat, vitamins and minerals (National Academy of Science, 1989). The soy-acha complementary blend with 40% soybean has the best average composition of nutrients for infant feeding. It has the highest amount of protein (2.18%), fat (9.43%), ash (3.45%) and crude fiber (1.86%) but relatively low in carbohydrate (65.55%). The low moisture content (6.25%) of this sample with 40% soybean flour is likely to help in its longer shelf life than the other samples.

Mineral Composition of Soy-Acha Complementary Weaning Foods (mg/100g)

The calcium, phosphorus and iron contents of the soy-acha complementary blends are shown in Table 5. Soy flour addition did not affect phosphorus content of the blends. Phosphorus was relatively low at 1.0% content in all the blends. This implies that each of soy and acha flours had about the same 1.0% phosphorus content that always resolved back at all 100% complementary blends. Calcium content increased with the addition of soy flour and ranged from 20 to 31 mg/100g for 10% to 40% soy flour addition but was at 17.0mg/100g for 100% acha flour. The iron content also increased with the addition of soy flour but was not always proportional. This implies uneven distribution of iron in the acha and soy flours. Calcium and phosphorus are important for development of strong bones and teeth while iron is important for heme iron in red blood formation and healthy living of the child.

Table 5: Mineral composition of Soy-acha complementary food (mg/100g)

	Sf(10%)	Sf(20%)	Sf(30%)	Sf(40%)	Sb(10%)	Sb(20%)	Sb(3%)	Sb40%	Af(100%)
Calcium (Ca)	20±0.00	20±1.00	24±2.00	31±2.00	20±0.01	27±1.00	28±1.00	31±1.01	17±0.00
Phosphorus (P)	1.0±0.00	1.0±0.00	1.0±0.00	1.0±0.00	1.0±0.00	1.0±0.00	1.0±0.00	1.0±0.00	1.0±0.00
Iron (Fe)	221±3.0	520±2.0	340±1.0	180±2.0	134±1.0	249±2.0	299±2.0	180±2.5	ND

As= 100 % acha flour; sb.(10%), sb (20%), sb (30%), sb (40%) = soy-acha mixes with 10%, 20%, 30%, 40% blanched (30 min.) soybeans respectively; sf (10%), sf (20%), sf (30%), sf (40%) = soy-acha mixes with 10%, 20%, 30%, 40% fermented (18h) soybeans respectively. Values are Means ± Standard deviations of three determinations.

Sensory Analysis

The sensory scores on a 9 point hedonic scale of the blend sample from 15- member panelists is shown in Table 6. The sensory scores for colour, texture, flavour, mouth feel and overall acceptability ranged from 7.13 to 8.13. None of the attributes had average mean score less than the mean mark (4.5) of the 9-point scale. All the sample were generally accepted by the consumers.

Table 6: Sensory properties of soy-acha weaning foods

Treatment	Colour	Texture	Flavour	Mouth feel	Overall acceptability
Sf (10%)	7.07±0.36^{b}	7.27±0.37^{a}	7.93±0.22^{b}	7.67±0.21^{ab}	8.13±0.26^{a}
Sf (20%)	8.00±0.23	7.80±0.32^{b}	7.26±33^{a}	7.86±0.17^{ab}	7.47±0.24^{b}
Sf(30%)	7.60±0.25^{ab}	7.80±0.27^{b}	7.60±0.33^{b}	8.07±0.20^{a}	8.00±0.26^{a}
Sf(40%)	7.87±27^{ab}	7.48±0.32^{ab}	7.93±0.30^{b}	8.00±0.21^{a}	7.80±0.26^{ab}
Sb(10%)	7.47±0.25^{b}	7.13±0.25^{a}	7.76±0.39^{b}	7.40±0.33^{b}	7.18±35^{b}
Sb (20%)	7.53±0.19^{b}	7.33±0.28^{a}	7.47±0.31^{ab}	7.68±0.25^{ab}	7.87±0.24^{ab}
Sb (30%)	7.73±0.22^{a}	7.40±0.21^{ab}	7.33±0.30^{ab}	7.35±0.37^{b}	7.33±0.37^{b}
Sb(40%)	7.60±0.25^{ab}	7.60±0.28^{ab}	7.13±0.31^{a}	7.22±0.37^{b}	7.27±0.30^{b}
Af (100%)	8.13±0.19^{a}	7.52±0.40^{ab}	7.30±0.39^{a}	7.87±0.29^{ab}	8.00±0.24^{a}
Nutrend	8.16±0.26^{a}	7.82±0.25^{b}	7.46±0.22^{ab}	8.16±0.18^{a}	7.98±0.27^{a}

AS=100% acha flour; sb.(10%), sb (20%), sb (30%), sb (40%) = soy-acha mixes with 10%, 20%, 30%, 40% blanched (30 min.) soybeans respectively; sf (10%), sf (20%), sf (30%), sf (40%) = soy-acha mixes with 10%, 20%, 30%, 40% fermented (18h) soybeans respectively; values are Means ± Standard deviations of three determinations and values with the same superscripts are not significantly (p 0.05) different.

CONCLUSION

The result of this study showed that fermentation and blanching improved the nutritive values of soybean, and that complementing acha with soy bean increased protein, fat, fibre, ash, calcium and iron contents of the blends. It decreased the digestible carbohydrate contents. The deceased carbohydrate content is advantageous in reducing blood sugar level of the consumer. The sensory scores also indicated overall acceptability of all the products. However the samples with 40% fermented or blanched soy flour is mostly recommended based on the proximate composition and acceptability.

REFERENCES

Akobundu E.N.T., 1992. Non-Soya vegetable food blends in infant feeding: an overview. MIFST-EAST Symposium Series, **2**(1): 32-44.

AOAC,1990. Association of Official Analytical Chemists, Official Methods of Analysis,15th ed,. Washington D.C.: 35-56.

Carvalino AV., Garcia N.H and Amaya Fahran J., 2006. Physico-chemical properties of the flour, protein concentrate, and protein isolate of the Capuassu (Theobromagrandiflourm Schum) Seed. Journal of Food Science, **71** C83: S573-S577.

Chakraverty A., 2004. Post Harvest of Oil Seeds. Oxford and IBH Publishing Company, Pvt. Ltd, New Delhi, India: 339

Inyang C.U. and Idoko, C.A., 2006. Assessment of the Quality of Ogi made from malted millet. African Journal of Biotechnology, **5**: 2334-2337.

Mellgaard M. Civille C.V and Carr, B.T.,1998. Sensory Evaluation Technique, 3rd ed. CRC Press Inc,. Boca Raton.

National Academy of Science, 1989. Recommended Dietary Allowances, 11th ed. National Academy Press, Washington D.C.

Temple V.J and Bassa, J.D., 1991. Proximate chemical composition of acha (Digitaria exillis) grain. Journal of Science of Food and Agriculture, **56**: 561-563.

Okoh P.N.,1998. Cereal grains in: Nutritional Quality of Plant Foods, (Eds) Osajie, A.U. and Eka O.U. Post/Harvest Research Unit, University of Benin City :32-52.

Onwuka G.I., 2005. Food Analysis and Instrumentation, 1st ed. Naphthali Print, HG Ltd, Lagos Nigeria: 70-71.

SAS, 2002. User guide. Release 8.2 ed. Cary M.C SAS Inst. Inc. USA.

WHO, 2004. Complementary feeding of young children in developing countries. www.who.int/child.adolescent.health/NLIR.111on/complementary htm.:224.