British Journal of Applied Science & Technology
2(4): 356-366, 2012

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Nutritional and Sensory Characteristics of an Infant Food Based on Soybean Seeds (*Glycine max*) and Tigernut Tubers (*Cyperus esculenta)*

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Authors' contributions

This work was carried out in collaboration between all authors. CAEI designed the study, wrote the protocol and the first draft of the manuscript; IOE managed the analyses of the study; GOI managed the literature searches. All authors read and approved the final manuscript.

Research Article

Received 21st March 2012
Accepted 12th September 2012
Published 15th October 2012

ABSTRACT

Aims: To evaluate the nutritional and sensory characteristics of soybean *and tigernut based infant food that could be adoptable at house-hold* level by rural dwellers.
Study Design: Randomized design.
Place and Duration of Study: Department of Biochemistry, University of Calabar, between January 2009 and 2010.
Methodology: Soybean seeds were washed, soaked overnight, cooked, dehulled, dried and milled into flour to pass a 300µm sieve. Tigernut tubers were washed, soaked for 96h, dried and milled into flour (300µm). Three weaning foods; STF1 (Tigernut: 75%; soybean: 15%); STF2 (Tigernut: 65%; Soybean: 25%); STF3 (Tigernut: 55%; Soybean: 35%) with 10% full cream powdered milk (FCM) each were prepared to yield formulated weaning food (FWD). Samples were assayed for proximate, energy, pH, mineral and organoleptic qualities. The control was a commercial brand based on maize, soybean, FCM and additives.
Results: Proximate, energy and mineral contents of the samples were different (P<0.05). FWDs contained higher (P<0.05) amounts of protein, ash, fat, fiber, energy and mineral contents than the control. STF3 recorded higher (P<0.05) ash, protein, fiber, calcium, potassium, magnesium, iron and zinc. Among the FWDs, STF3 had higher (P<0.05) panelists ratings for all the sensory attributes and it compared favorably with the control.

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STF3 was rated higher (P<0.05) for overall acceptability compared to the control. The result suggested that STF3 hold a potential promise for the delivery of cheap nutrient dense infant food for low income house-holds.

Conclusion: The potential suitability of tigernut flour in weaning food formulation was shown in this study. Although all the formulated diets met the benchmark for infant food, taking into consideration the dietary profile and sensorial ratings, STF3 (Tigernut 55%; Soybean 35%, 10% milk) was found to be the most promising formulation. This indicates that underutilized tigernut tubers could be exploited to produce adoptable household cheap weaning food with soybean that can compare favorably with commercial brand. This could be a sustainable way of curbing malnutrition in sub-Saharan Africa.

Keywords: Infant food; tigernut tubers; soybean seeds; proximate; mineral; sensory evaluation.

1. INTRODUCTION

Infants and young children suffer from malnutrition in most developing countries. The growth of infant in the first and second year of life is very rapid and breast milk alone cannot meet the child's nutritional requirements. The infant needs supplementary feeding starting from 4-6 months (Achinewhu, 1987; Ijarotimi and Famurewa, 2006). Many brands of preparatory foods have been developed and marketed; however these brands are too expensive and therefore are beyond the economics of low income families. The high price of proprietary weaning food and animal proteins combined with faulty feeding practices are mostly responsible for aggravating malnutrition among children (Dutra-de –Olivera, 1991). Protein energy malnutrition (PEM) generally occurs during the crucial transitional phase when children are weaned from liquid to semi solid or fully adult foods. Children therefore require nutritionally balanced calorie-dense supplementary foods in addition to mother's milk (Berggren, 1982; Cameroon and Hafvander, 1971). Several studies have reported that most of the weaning foods consumed by children in many parts of developing nations are deficient in essential macro and micro nutrients (Levin et al., 1993; Brabin and Coulter, 2003; Milward and Jackson, 2004). In view of this nutritional problem, several strategies have been used to formulate weaning food (Lalude and Fashakin, 2006; Ijarotimi and Ashipa, 2006; Ijarotimi and Bakare, 2006) through a combination of locally available under-ultilized food crops that complement each other.

Tigernut (*Cyperus esculentus)* is an underutilized readily available crop in Nigeria. It belongs to the family of *Cyperaceae*, which produce rhizomes from the base and are somewhat spherical. The tubers contain significant amount of protein, fat, minerals and vitamins (Alobo and Ogbogo, 2007; Oladele and Aina, 2007). In addition, tigernut tubers could be used for the treatment of flatulence, indigestion, diarrhea, dysentery and excessive thirst (Chevallier, 1996). The use of such readily available underexploited crop to complement with legumes such as soybeans in developing a simple household low cost weaning food hold promise in alleviation of infant malnutrition. The challenge therefore is to develop a nutrient dense supplementary infant food from locally available underutilized crops that could be adoptable at the household level. Therefore, the objective of the study was to evaluate the nutritional and sensory characteristics of soybean and tigernut based infant food.

2. MATERIALS AND METHODS

Soybean seeds *Glycine max)* and tigernut tubers (*Cyperus esculentus*), 1000 kg each were purchased from an open market (Calabar, Nigeria) and stored at 4ºC until processed. Full cream milk powder (FCM) was purchased from a grocery store (value mart). All the chemicals were of analytical grade purchased from Sigma Aldrich (Germany).

2.1 Preparation of Soybean and Tigernut Flour

After cleaning and removal of broken seeds and extraneous materials, the soybean seeds were washed and soaked in 4-times volume of potable water for 12 h to reduce flatulence – causing oligosaccharides by leaching them into the water. The seeds were drained and cooked for 30 min with potable tap water twice its volume and then dehulled. The soybeans were dried in an oven (Gallenkamp Plus 11) at 65ºC for 24 h and then milled using a hammer mill (Christy & Norris Ltd., Chelmsford, England), to pass through a 250 µm stainless sieve (W. Styler Co., Mentor, Ohio, USA) to obtain soybean flour (SF) (Akapo et al., 1995).

The method of Ade-Omowaye et al. (2008) was used in the production of tigernut flour (TF). Tigernut tubers were sorted to remove damaged and other extraneous materials, washed with potable water and soaked for 96h in potable water 4 times its volume. The sample was dried in a cabinet dryer at 65ºC for 24h and then milled to pass through 250µm sieve size to obtain tigernut flour (TF). The flour samples were stored in high density polyethylene pouches at -4ºC until used for analysis.

2.2 Weaning Food Formulation

Three diet formulations: STF_1, STF_2 and STF_3 in duplicates were prepared by mixing varying proportions of the flours with 10 percent full cream milk powder (FCM) as shown in Table 1.

Table 1. Percentage Composition for formulation of Tigernut and Soybean weaning food

Composite	Percent dry weight basis		
	TF	**SF**	**FCM**
STF_1	75	15	10
STF_2	65	25	10
STF_3	55	35	10

SF: Soybean Flour; Tigernut Flour: TF; FCM: Full cream milk

2.3 Chemical Analysis

The moisture, crude fat, crude protein and ash content were determined according to the method of AOAC (1997). Crude fiber was determined by the method of Joslyn (1970). Carbohydrate content (i.e nitrogen free extracts) were determined by subtracting the sum of weights of protein, fiber, lipid and ash from the total dry matter (AOAC, 1996). Caloric value of the samples was obtained by multiplying the values of crude protein, fat and carbohydrate by their respective physiological fuel values of 4, 9, 4 (Zou et al., 2007). The method of Murphy et al. (2003) was used to determine pH (Beckman Zeromaticiv pH meter). Mineral elements; calcium, magnesium, potassium, sodium, phosphorus, iron and zinc were determined using Atomic Absorption Spectrophotometer (Pelkin Elmer 129 B) according to the method of AOAC (1990). All the analyses were done in duplicates and each reading in triplicates.

2.4 Sensory Evaluation

Samples were subjected to sensory evaluation using the method of Larmond (1977). 50g sample was reconstituted in 20 ml boiled water cooled to 60ºC and then served warm (40ºC) to thirty panelists consisting of untrained nursing mothers. Each panelist was asked to rate the samples (which were identified by 3-digit random numbers) twice for appearance, color, mouth feel, consistency, taste, aroma and overall acceptability using 9 point hedonic scale, where 1 was extremely inferior to R and 9 was extremely better than R (Control). The control was a commercial brand based on maize, soybean, full cream milk and additives. The panelists were supplied with crackers and bottled water at room temperature (25ºC) to rinse their mouth between samples.

2.5 Statistical Analysis

All experimental results are the averages of three parallel measurements (means ± SD). Quantitative data were expressed as means and standard deviation (SD) of at least 3 measurements. Each experimental set was compared with one way analysis of variance (ANOVA) procedure using Statistical Package for Social Sciences (SPSS) version 11.5 (SPSS Inc., Chcago, IL, USA). Duncan's new multiple range test was used to determine the differences of means. P values <0.05 were regard as significant.

3. RESULTS AND DISCUSSION

3.1 Chemical Composition

The chemical compositions of the samples were significantly (P<0.05) different (Table 2). Moisture content values ranged from 3.10 ± 0.18% to 4.01 ±0.25%, with the highest value for control. The moisture content of the samples was below the moisture standard of 5-10% set by the Protein Advisory Group, (PAG, 1971). The low moisture content of the FWD would have a positive effect on shelf stability, as moisture could lead to product spoilage due to oxidation reactions (Bassey, 2004). The ash content of the samples ranged from 2.49±0.15% to 3.06±0.34%. The FWD had significantly (P<0.05) higher ash content, and the highest value was for STF3. The increased ash content of STF3 could be due to the high ratio of both the tigernut and soybean, as both are good sources of minerals.

Protein values ranged from 18.80±0.32% to 25.81±0.18%. The FWD had significantly (P<0.05) higher protein content. There was a progressive increase in the protein value with increase in soybean addition. The control had the least protein value. Protein content of FWD met the PAG (1971) of the United Nations protein standard for weaning food.

The fat content ranged from 10.10±0.26% for the control to 18.45±1.20% for the STF1. Fat content of the FWD were significantly higher (P<0.05) than the control. There was also a progressive increase in the fat content with increase in tigernut flour, the least being for STF3. This may be due to the higher level of fat (32.88%) in tigernut tubers (Addy and Eteshola, 1984). A fat content of 7.7±0.3%-17.3±0.4% was reported by Ade-Omowaye et al. (2008) for wheat and tigernut composite bread. However, the fat contents of the FWDs were higher than the recommended PAG value for weaning food. Hence, partial defatting of the tigernut tubers before utilization might yield better result, though fat is important in the infant diet because it contains essential fatty acids which promote good health. It is also a carrier of fat soluble vitamins promoting the absorption of vitamin A and carotene (Bogert et al., 1973).

Fiber values of the samples ranged from 2.50±0.56% for control to 4.86±0.41% for STF1. The fiber values of the FWDs were significantly ($P<0.05$) higher than the control. Fiber values increased with increase in tigernut flour. The fiber values of the samples were within the recommended PAG (1971) of 5%. Ade-Omowaye et al. (2004) reported a fiber value of 0.8±0.1% to 3.2±0.1% for wheat and tigernut composite bread. The fiber content of the FWDs was higher than those reported by Akapo et al. (1995), Sheikah et al. (1986) and Abbey and Mark (1998). Dietary fiber is reported to have some beneficial effects on the muscles of the large and small intestine (Fisher and Bender, 1977). However, a high fibre diet is believed to have some adverse effect on mineral elements in the body (Davidson et al., 1975).

Carbohydrate content ranged from 50.51±0.25% (STF_3) to 62.10±0.15% for control. The carbohydrate value for control was significantly ($P<0.05$) higher than the FWD. Energy value ranged from 408.01±0.28 kcal/100g for control to 502.21±0.33kcal/100g for STF1. The energy values of the FWD were significantly ($P<.05$) higher than the control. The highest value of energy for STF1 may be due to the higher fat content (18.45±1.20%) compared to the other samples, and moreover, the lowest fat value for control (4.10±0.126%) resulted in the lowest energy yield for the control. The pH value varied from 6.34±0.02 for STF1 to 6.42±0.25 for control. pH values of the samples were not significantly ($P<0.05$) different and ranged within alkaline region. Diets high on acid producing foods disrupts the normal slightly alkaline of the blood and therefore promotes the loss of essential minerals such as potassium, magnesium, calcium and sodium as the body tries to restore it. Alkaline diets may help to prevent diseases.

3.2 Mineral Composition

The mineral contents of the samples were significantly ($P<0.05$) different (Table 3) amongst all the samples. The calcium value varied from 81.08±0.26mg kg^{-1} for STF1 to 420.14±0.55 mg kg^{-1} for control. The control had significantly higher ($P<0.05$) calcium value than the FWD, which may be that the Control was fortified with calcium by the manufacture. The values reported for the FWD were higher than that reported by Thathola and Sarita (2002), in weaning gruel made from millet. Growing children need adequate amount of calcium for growth and optimal ossification of the bone and strength of the teeth to occur. The potassium values of the FWD were significantly ($P<0.05$) lower than the control. The values ranged from 437.45±0.16 mg kg^{-1} (STF1) to 500.30±0.20 mg kg^{-1} (control). Potassium aids in transmitting nerve impulses and also has a catalytic role in energy metabolism that results in making energy available from carbohydrate, fat and protein (Haas, 2010).

Sodium values varied from 21.24±0.31 mg kg^{-1} for STF1 to 220.09±0.31 mg kg^{-1} for control. Sodium is required in the body for its role in the maintenance of the water balance and body pH. Its deficiency causes reduction in the utilization of the digested protein and energy (Wedro, 2012). Phosphorus values ranged from 270.33±0.45 mg kg^{-1} (STF1) to 315.25±0.48 mg kg^{-1} for control ($P<0.05$). There was a gradual increase in phosphorus level as soybean flour increased. Phosphorus like calcium serves as a structural component of bones and teeth, and also is concerned with the release and transfer of energy inside the cells (Institute of Medicine, 1997).

Table 2. Chemical composition of tigernut and soybean flour based weaning diets

Constituents			STF3	CONTROL	SON (1988)	PAG (1971)	Methods
Moisture %	3.13±032^{b}	3.12±0.21^{b}	3.10±0.18^{b}	4.01±0.25^{a}	5-10 (Max)	5-10 (Max)	AOAC (1997)
Ash (%)	2.50±0.30^{C}	2.80±0.28^{b}	3.06±0.34^{a}	2.49±0.15^{c}	10 (Max)	10 (Max)	AOAC (1997)
Protein (%)	20.73±0.46^{a}	21.44±0.17^{b}	25.81±0.18^{a}	18.80±0.32	14-17% (Min)	20 (Min)	AOAC (1997)
Fat (%)	18.45±1.20^{a}	16.01±1.36^{b}	13.75±1.40^{c}	10.10±0.26^{d}	10 % (Max)	10 %(Max)	AOAC (1997)
Fiber (%)	4.86±0.41^{a}	4.50±0.35^{b}	3.77±0.21^{c}	2.50±0.56^{d}	5 %Max	5 % (Max)	Joslyn (1970)
Carbohydrate (%)	50.33±0.10^{d}	52.13±0.20^{b}	50.52±0.25^{c}	62.10±0.15^{a}	50% (Min)	-	AOAC (1996)
Energy (kcal/100g)	502.21±0.33^{a}	491.81±0.19^{b}	442.40±0.26^{c}	408.11±0.28^{d}	350-400	400	Zou et al (2007)
pH	634±0.02^{a}	6.39±0.02^{a}	6.41±0.20^{a}	6.42±0.05^{a}			Murphy et al (2003)

Table 3. Mineral composition of tigernut and soybean based weaning food

Element	STF1	STF2	STF3	Control	Methods
Macro element					
Cal (mg kg^{-1})	81.08±0.26^{d}	82.46±0.56^{c}	86.02±0.47^{b}	420.14±0.53^{a}	AAS(AOAC 1990)
Potassium (mg kg^{-1})	437.45±0.16^{c}	440.42±0.51^{b}	447.39±0.42^{b}	500.30±0.20^{a}	AAS(AOAC 1990)
Sodium (mg kg^{-1})	28.12±0.61^{b}	21.24±0.31^{c}	16.45±0.21^{d}	220.09±0.30^{a}	AAS(AOAC 1990)
Phosphorus(mg kg^{1})	270.33±0.45^{C}	276.56±0.39^{c}	289.29±0.26^{b}	315.25±0.48^{a}	AAS(AOAC 1990)
Micro element					AAS(AOAC 1990)
Magnesium(mg kg^{1})	81.02±0.48^{c}	86.12±0.28^{b}	96.04±0.31^{a}	NA	
Iron (mg kg^{-1})	4.13±0.09^{d}	6.34±0.21^{c}	8.51±0.28^{b}	10.34±0.02^{a}	AAS(AOAC 1990)
Zinc (mg kg^{-1})	6.63±0.18^{c}	7.85±0.24^{b}	8.52±0.34^{a}	7.83±0.22^{b}	AAS(AOAC 1990)

Means of three determination. Values not followed by the same letter in the same row are significantly different ($P<0.05$). STF_1 (Tigernut 75%, Soybean, 15%), STF_2 (Tigernut: 65%, Soybean: 25%), STF_3 (Tigernut: 55%, Soybean 35%), Control: Commercial brand.

Magnesium content varied from 81.02±0.48 mg kg^{-1} for STF1 to 96.04 mg kg^{-1} for STF3, which increased with increase in soybean ratio. Magnesium value was not available for the control. Magnesium is a minor component of bones and is equally present in soft tissues. Though magnesium deficiency is rare (Brody, 1994), its role in growing children is associated with the promotion and retention of calcium in tooth enamel, thus increasing resistance to dental carries and loss of teeth (Stare and McWilliams,1977).

Iron content ranged from 4.13±0.09 mg kg^{-1} for STF1 to 10.34±0.02 mg kg^{-1} for control ($P<0.05$). The iron values of FWD increased as soybean level progress. Iron in the body aid the transport of oxygen for red blood cells formation. It is also a component of the enzymes that catalyze oxidation-reduction reactions in the glucose and fatty acid metabolism (Stare and McWilliams, 1977). Deficiency of iron over a period of time is characterized by poor growth, decreased pigmentation in the interior of the mouth, increased heart and respiration rates (Hallberg, 1986). STF3 would satisfy the iron requirement of an infant. Zinc level varied from 6.63±0.18 mg kg^{-1} for STF1 to 8.52±0.34 mg kg^{-1} for STF3, decreasing with increase in tigernut flour level amongst the FWD. Zinc value for STF3 was significantly ($P<0.05$) higher than the other FWD and the control. The Zinc level of FWDs was higher than 1.9 mg kg^{-1} reported by Akapo et al. (1995) and also was above the 1.3 mg kg^{-1} minimum daily allowance recommended for infants. Zinc activates enzymes needed in protein metabolism and also forms part of carbonic anhydrase, the enzyme that is prominent in carbon (IV) oxide transfer. It is involved with many enzymes as cofactor for the metabolic action and is also closely associated with insulin, carbohydrate metabolism and regulating hormone (Stare and McWilliams, 1977). Deficiency causes growth retardation and delayed sexual maturation (Underwood, 1971). The results showed that FWD especially STF3 contained appreciable amounts of macro and micro elements and hence would be suitable for an infant food.

3.3 Sensory Evaluation

The mean panelists rating of the sensory attributes of the FWD and control are shown in Table 4. Appearance rating was significantly ($P<0.05$) different and the values ranged from 7.16 for STF1 to 8.00 for STF3. The lower rating for STF1 and STF2 may probably be due to unattractive dull appearance of the samples, as a result of higher percentage of tigernut flour, which yielded high fiber value. Consequently, appearance rating showed a high inverse correlation (-0.835) with fiber value (Table 5). The FWD appearance ratings increased with soybean ratio increase. Color ratings ranged from 7.08 (STF1) to 8.12 (STF3). There was no difference ($P<0.05$) between STF3 and control and between STF1 and STF2. Panelists rated the samples lower with increase in tigernut flour. However, panelist ratings for all the samples were above the mid-point and therefore were acceptable. Color rating showed a significant high inverse correlation (Table 5) with fat content (-0.752) and fiber (-0.848) respectively. Color is an important quality indicator of a food system that could affect consumer acceptance. The ratings for mouthfeel ranged from 6.80 (STF1) to 7.96 (control), but the ratings between STF_3 and control was not different ($P<0.05$). The control sample was rated higher for mouthfeel while STF1 was rated least ($P<0.05$). Similar trend was observed for mouthfeel as was for appearance and color. Mouthfeel rating (Table 5) showed an inverse correlation with fat content (-0.788) and fiber content (-0.865), indicating that these parameters affected the mouthfeel attribute negatively

Table 4. Mean panelist ratings for tigernut and soybean flour based weaning food

Parameters	Sample			
	STF1	STF2	STF3	Control
Appearance	7.16^{c}	7.48^{b}	8.00^{a}	7.96^{b}
Color	7.08^{b}	7.16^{b}	8.12^{a}	8.08^{a}
Mouthfeel	6.80^{c}	7.28^{b}	7.92^{a}	7.96^{a}
Consistency	7.14^{b}	7.16^{b}	8.08^{a}	7.92^{a}
Taste	6.92^{c}	7.00c	8.12^{a}	7.48^{b}
Aroma	7.44^{c}	7.68^{b}	8.12^{a}	7.24^{d}
Overall acceptability	7.44^{d}	7.64^{c}	7.96^{a}	7.68^{b}

Higher values indicate greater preference. Means of three determination. Values not followed by the same letter in the same row are significantly different (P<0.05). STF_1 (Tigernut 75%, Soybean, 15%), STF_2 (Tigernut: 65%, Soybean: 25%), STF_3 (Tigernut: 55%, Soybean 35%), Control: Commercial brand.

The mouthfeel determines the amount of food that could be consumed because infants can only swallow a smooth gruel. Consistency ratings ranged from 7.14 (STF1) to 8.08 (STF3), and there was no difference (P<0.05) between STF3 and control and between STF1 and STF2. The higher consistency rating of STF_3 may be due to higher protein value (Table 2). Dev and Quensil (1988) reported that protein sub-unit has increased number of hydrophilic groups, which are the primary sites of water binding and hence better consistency. Increase in the ratio of tigernut flour showed a reduction in the consistency rating, which could also be attributable to the relative ratios of different constituents; protein, carbohydrate and lipids in flours (Sath et al., 1982). Fat content (-0.676) and fibre content (-0.785) were significantly negatively correlated with consistency. Taste rating varied from 6.92 (STF1) to 8.12 (STF3), which had higher rating compared to the control (P<0.05). Increase in the level of tigernut flour caused reduction in taste rating. An inverse correlation value for fibre content (-0.525) and positive values for ash content (0.663) and protein content (0.672) were observed with panelist taste rating (Table 5).

Table 5. Correlation analysis of proximate composition with sensory properties

	Ash	Protein	Fat	Fibre	Carbohydrate
Appearance	0.430	0.296	-0.747*	-0.835*	0.507
Color	0.315	0.271	-0.752*	-0.848*	0.522
Mouth feel	0.381	0.229	-0.788*	-0.865*	0.562
Consistency	0.382	0.365	-0.676*	-0.785*	0.429
Taste	0.663*	0.672*	-0.383	-0.525*	0.086
Aroma	0.974*	0.985*	0.414	0.279	-0.671*

***** *Significant relationship (P<0.05)*

However, the ratings of the FWD were above the mid-point for acceptability. Taste is an important sensory attribute which determine products acceptability especially by an infant. Aroma ratings ranged from 7.24 (control) to 8.12 (STF3). The panelist ratings for aroma were different (P<0.05), and the FWD had higher (P<0.05) ratings than the control. This may be attributed to the flavor imparted by the nutrient interactions of the samples. Correlation analysis showed a positive value for aroma and ash (0.974) and protein (0.985) and inverse value for carbohydrate (-0.671). Overall acceptability rating ranged from 7.44 (STF1) to 7.96 (STF3) and the values were different (P<0.05). The overall acceptability value of STF3 was higher (P<0.05) than the control. Equally, among the FWD, STF3 had the highest (P<0.05) overall acceptability rating.

4. CONCLUSION

The potential suitability of tigernut flour in weaning food formulation was shown in this study. Although all the formulated diets met the benchmark for infant food, taking into consideration the dietary attributes and sensorial ratings, STF3 (tigernut 55%; soybean 35%, 10% FCM) was found to be the most promising formulation among three investigated variants. This indicates that underutilized tigernut tubers could be exploited to produce adoptable household cheap weaning food with soybean that can compare favorably with commercial brand. This could be a sustainable way of curbing malnutrition in sub-Saharan Africa.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the assistance of Ms Emen in the manuscript preparation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

AOAC. (1997). Official methods of analysis of the association of official analytical chemists. Virginia, USA.

AOAC. (1996). Official methods of analysis. 16th (ed). Association of Official Analytical Chemists, Washington, DC.

AOAC. (1990). Methods of analysis of the association of official analytical chemist, 15 ed. Washington DC, USA.

Alobo, A.P., Ogbogo, P.O. (2007). Selected properties of tigernut starch as affected by physical and chemical modification. Proceedings of the 31st Annual NIFST Conference, Abuja, Nigeria. 22-25th October 2007.

Abbey, D.W., Mark, B.T. (1988). Nutritional quality of weaning foods prepared from composite flour of maize, unfermented and germinated cowpea. Nutritional Report International, 38(2), 519-526.

Achinewhu, S.C. (1987). Protein quality evaluation of weaning food mixtures from indigenous fermented foods. J. Nutri Sci, 8, 23-30.

Addy, E.O., Eleshola, E. (1984). Nutritive value of a mixture of tigernut tubers and baobab seeds. J Science Food Agric, 35, 437-440.

Ade-Omowaye, B.I.O., Akinwande, B.A., Bolarinwa, I.F., Adebiyi, A.O. (2008). Evaluation of tigernut (*Cyperus esculentus*) wheat composite flour and bread. African J Food Sci, 2, 87-91.

Akapo, S.O., Oguntade, A.T., Ogundare, O.F. (1995). Nutritional evaluation of food formulation prepared from soybean, sorghum and crayfish. Nigerian Food Journal, 13, 1-2.

Bogert, J.L. Briggs, G.M., Galloway, D.H. (1973). Nutrition and Physical fitness. Philadelphia W.B. Saunders.

Berggren, G.G. (1982). Questions and answers about weaning. Food Nutrition Bull., 4(1), 20-24.

Brody, T. (1994). Nutritional Biochemistry. New York. Academic Press.

Brabin, B.J., Coulter, J.B.B. (2003). Nutrition associated disease. In: Cook, G.C. Zumla, A.I. (Eds), Manson's Tropical Diseases. Saunders, London, 561-580.

Bassey, F. (2004). Chemical Composition, functional Properties and shelf life study of weaning food processed from cooking banana. Unpublished Ph.D. thesis, University of Calabar, Nigeria.

Chavallier, A. (1996). The encyclopidia of medicinal plants. Dorling Kindersley, London.

Cameroon, M., Hofvander, Y. (1971). Manual on feeding infants and young children PAG Document, 14, 25-26.

Dutra-de-Olivera, J.E. (1991). Malnutrition in developing countries: the challenges to the responsibilities of the experts. Proc. Nutri Soc. India, 37, 29-38.

Davidson, S., Passmore, R., Brock, J.F., Truswell, A.A. (1975). Human nutrition and dietetics. 6^{th} ed.London. Churchill Livingston.

Fisher, P., Bender, A.E. (1977). The value of food. Oxford: Oxford University Press.

Hallberg, L. (1982). Iron absorption and iron deficiency. Hum Nuri Clin Nuri, 36, 259-278.

Haas, E.M. (2000). Role of potassium in maintaining health. Available at hkpp.org/patients/potassium health. Accessed May 21, 2012.

Ijarotimi, O.S., Famurewa, J.A.V. (2006). Assessment of chemical composition of soybean supplemented weaning foods and nutritional knowledge of nursing mothers on their utilizations. Pak J. Nutri, 5, 218-228.

Ijarotimi, O.S., Bakare, S.S. (2006). Evaluation of proximate, mineral and antinutritional factor of home processed complementary diets from locally available food materials (*Sorghum bicolour* and *Sphenostylis stenocarpa*). J Food Tech, 4(4), 339-344.

Ijarotimi, O.S., Ashipa, F. (2006). Evaluation of nutritional composition, sensory and physical properties of home processed weaning food based on low cost locally available food materials. Nutri and Food Sci, 36(1), 6-17.

Institute of Medicine. (1997). food and nutrition board dietary reference intake for calcium, phosphorus, magnesium, vitamin D and floride. National Academy Press, Washington.

Joslyn, M.N. (1970). Methods in food Analysis 2^{nd} Ed. Academic Press, New York, London.

Larmond, E. (1977). Methods of sensory evaluation of food research institute, central experimental farm, Ottawa, Canada. Publication NO 1637.

Lalude, L.O., Fashakin, J.B. (2006). Development and nutritional assessment of a weaning food from sorghum and oil-seeds. Pakistan J Nutr, 5(3), 257-260.

Levin, H.M., Pollitt, E., Galloway, R., McGuire, J. (1993). Micronutrient deficiency disorders, in: Jamison.

Milward, D.J., Jackson, A.A. (2004). Protein/ energy ratios of current diets in developing countries compared with a safe protein/energy ratio: implications for recommended protein and amino acid intakes. Public Health Nutr, 7, 387-405.

Murphy, M.G., Skonberg, D.J., Camire, M.E. (2003). Chemical composition and physical properties of extruded snacks containing crab-processing –by-product winged bean flour for food. Food Science, 47, 1534-1538.

Oladele, A.K., Aina, J.O. (2007). Chemical composition and functional properties of flour from two varieties of tigernut (*Cyperus esculentus*). Afri J Biotech, 6(21), 2474-2476.

Protein Advisory Group (PAG) Guide. (1972). Guideline on protein – rich mixture for use as weaning food. New York: United Nations.

Qev, D.K., Quensil, E. (1988). Preparation and functional properties of linseed protein product containing differing levels of vegetable protein products. J Food Sci, 40, 805.

Sathe, S.K., Desphande, S.S., Salunke, D.K. (1982). Functional properties of winged beans (*Phosphocarpus tetragonolobus (2) DC*) Protein. J. Food Sci, 47, 503-509.

Stare, F., McWilliams, M. (1977). Living Nutrition, New York, John Wiley and Sons.

Sheikah, I.A., Arshad, Aslam, M., Adil, R. (1986). Preparation and nutritional evaluation of weaning food based on wheat, rice and soybean (SOYLAC). Pakistan Journal of Science, 129, 151-154.

Thathola, A., Sarita, S. (2002). Physicochemical properties and nutritional traits of millet based weaning food suitable for infant of the Kumaon hills, Northern India. Asia Pacific Journal of Chemical Nutrition, 2(1), 28-32.

Underwood, E.J. (1977). Trace element in human and animal nutrition. New York, Academy Press.

Wedro, B. (2012). Electrolytes-sodium, potassium, calcium, and biocarbonate. Available at WWW.emedicinehealth.com. Accessed May 2012.

Zou, M.L., Moughan, P.J., Awati, A., Livesey, G. (2007). Accuracy of the Atwater factors and related food energy conversion factors with low-fat, high fiber diets when energy intake is reduced spontaneously. Am J Clin Nutri, 86, 1649-56.