

Research paper

PHYSICOCHEMICAL PROPERTIES OF SORGHUM BISCUIT ENRICHED WITH DEFATTED SOY FLOUR.

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ABSTRACT

Aims: To evaluate the nutritional and sensory properties of sorghum biscuit enriched with defatted soy flour, at ratios that could reduce protein energy malnutrition.

Study design: Two way anova.

Place and Duration of Study: Department of Food science and Technology, Federal University of Technology, Akure, Nigeria.

Methodology: The sorghum whole grain used was milled into flour to pass a 500 µm sieve. The defatted soy flour was supplied by Jof – Ideal industry, Owo, Nigeria. Sorghum flour was blended with defatted soy flour at the following ratio – SD1 (70:30), SD2 (77.50: 22.50), SD3 (85.50:15.00), SD4(87.50:12.50), SD5(90.00:10.00), SD6 (95.00:5.00),and SD7 (92.50:7.50) respectively and blends were used for biscuit production.. The following analysis were carried out on the biscuit samples namely - proximate composition, mineral composition, physical characteristics and colour.

Results: Significant differences ($P = .05$) were observed in the proximate, energy and mineral compositions of the biscuits. The protein content ranged from 7.3 ± 0.2 – $11.2 \pm 0.2\%$; crude fat ranged from 12.0 ± 0.2 – $18.1 \pm 0.1\%$; crude fiber content ranged from 2.0 ± 0.0 – $3.8 \pm 0.0\%$ while the carbohydrate content ranged from 58.2 ± 0.2 – $70.6 \pm 0.1\%$. Results obtained compares favourably with the recommended dietary intake for each nutrient. The calculated energy value ranged from 1825.8 – 2026.1 KJ/100g. The Na:k ranged from 1.0 – 1.5 while the Zn:Cu ranged from 1.2 – 3.0. The diameter of biscuit ranged from 4.50 ± 0.14 – $5.80 \pm 0.14\text{cm}$; Weight ranged from 8.27 ± 0.03 – $8.90 \pm 0.14\text{g}$; thickness ranged from 0.62 ± 0.01 – $0.84 \pm 0.06\text{cm}$. Breaking strength ranged from 1.4 – 2.7N. No significant differences were observed in the L^* , a^* and b^* values of the biscuits.

Conclusion: Sorghum biscuits enriched with defatted soy flour met recommended dietary intake for each nutrients, hence formulated biscuits could therefore be a useful tool in reducing protein energy malnutrition.

Keywords: [Sorghum, defatted soy flour, biscuits, physicochemical properties]

1. INTRODUCTION

Protein energy-malnutrition (PEM) is a major cause of morbidity and mortality in young children in Africa and it continues to be a major public health problem throughout the developing world, particularly in southern Asia and sub-Saharan Africa (Schofield and Ashworth, 1996). It is therefore paramount to encourage the preparation of different portions of cereals – legumes to improve protein quality of the populace in sub-Saharan Africa.

Sorghum (*Sorghum bicolor* (L.) moench) is an important cereal grain with 60 million metric tonnes harvested from 44 million hectares in 2004 (FAO 2011). It is an important staple in Africa (Nigeria, Sudan, Ethiopia), Asia (India, China), and the drier part of central and south America (Dendy 1995), according to Rooney et al., 1986, 40% of the world wide sorghum production is used for human food consumption. Several developing countries have encouraged the initiation of programs to evaluate the feasibility of alternative locally available flour as a substitute for wheat flour. Many efforts have been carried out to promote the use of sorghum flour, in which a portion of wheat flour is replacement by locally grown crops to be used in bread, cake, thereby decreasing the cost associated with imported wheat (Olaoye et al., 2007). Enrichment of cereal-based foods with oil seed protein has received considerable attention. Soybean is a cereal- legume which contributes significantly towards protein, mineral, fat and B complex vitamins needs of people in developing countries. The usefulness of the grain legumes in developing high protein foods in meeting the needs of the vulnerable groups of the population is now well recognized, and several high protein energy foods have been developed industrially, in different parts of the world (Nkama, 1993). Supplementation of cereal flour with inexpensive staples such as legumes/ pulses helps in improving the nutritional quality of cereal product (Sharma et al., 1999).

Biscuits are one of the popular cereals foods; apart from bread, consumed in Nigeria, they are ready to eat, convenient and inexpensive food products, containing digestive and dietary principles of vital importance (Kulkarni, 1997). In Nigeria, snacks consumption is continually growing and there has been increasing reliance on imported wheat (Akpapunam et al., 1999).

The objective of this work is to study the physicochemical properties of sorghum biscuits enriched with defatted soy flour.

2. MATERIAL AND METHODS

Sorghum (*Sorghum bicolor*), margarine, sugar, salts, were purchased from an open market in Akure, Nigeria and stored at 4°C until use. The defatted soy flour was supplied by Jof – Ideal industry, Owo, Nigeria. All chemicals used were of analytical grade.

2.1 Preparation of sorghum flour

The sorghum whole grain were milled using a laboratory hammer mill (Falling Number 3100, Huddinge, Sweden) fitted with a 500 µm opening screen to give whole grain flour, which was then vacuum packed and stored at 4°C prior to usage. Sorghum flour was blended with defatted soy flour at the following ratio – Table 1.

Table 1: Formulation of flour blends for biscuit production

Blends	Sorghum Flour	Defatted Soy flour
SD1	70	30
SD2	77.50	22.50
SD3	85.00	15.00

SD4	87.50	12.50
SD5	90.00	10.00
SD6	95.00	5.00
SD7	92.50	7.50

2.3. Biscuit preparation

The margarine and sugar were creamed at low speed for 3 min, using a Kenwood Chef Food mixer Model A901. Sorghum flour and defatted soy flour were added and mixed with the cream for 2 min at low speed, to obtain firm dough. The dough was manually rolled out to a height of 5 mm and cut into circular shapes using a 4.3 cm diameter cutter. The dough pieces were transferred onto a baking tray lined with aluminium foil. Biscuit dough were baked in a pre-heated Unox steam convection oven at $160 \pm 2^{\circ}\text{C}$ for 20 min and cooled for 30 min at ambient temperature. Biscuits were vacuum packed in polyethylene bags and stored at 4°C .

2.4 Chemical Analysis

The proximate composition of biscuits was determined according to the standard methods of AOAC (2005). Carbohydrate content was calculated by difference and calculated energy value (Kcal/100g) was calculated using the Atwater factor (Okoye et al., 2008) and converted to KJ by multiplying values with 4.18. Mineral composition of biscuits was determined using the dry-ashing technique (Official method of analysis 935.13 AOAC, 2005). Ca, Fe, Zn and Mg content were quantified using atomic absorption spectrophotometer (Varian AA 240, Victoria, Australia) while Na and K contents were determined using flame photometer (Sherwood Flame Photometer 410, Sherwood Scientific Ltd. Cambridge, UK).

2.5 Physical Characteristics of biscuits

The weight and the diameter of the baked biscuits were determined by weighing on a weighing balance and measuring with a calibrated ruler respectively (Ayo et al., 2007). Thickness and spread ratio of biscuit were calculated as per the AOAC (2005) methods. Spread ratio was the ratio of the biscuit is diameter/ thickness after baking. The breaking strength was determined using an Instron texture analyzer according to the method described by Bajaj et al., (2006); Bheema et al., (2008).

Determination of colour

The colour of the biscuit was measured according to the method described by Rocha and Morais (2003) with a hand held tristimulus reflectance color meter. The color was recorded using a CIE–L*a*b* uniform color space (–Lab), where L* indicates lightness, a* indicates chromaticity on a green (–) to red (+) axis, and b* chromaticity on a blue (–) to yellow (+) axis. Numerical values of a* and b* were converted into hue angle and chroma value (Francis, 1980). The L* value is a useful indicator of darkening during storage resulting from oxidative reactions. The hue angle (H°) is an angle in a color wheel of 360°, with 0°, 90°, 180° and 270° representing the hues red-purple, yellow, respectively. It was derived as the arctangent of the ratio of CIE a* to CIE b* expressed as degrees (Nielsen, 1998). The chroma (C*) which is the intensity or purity of the hue was calculated as the square root of the sum of the squared values of both CIE a* and CIE b* (Nielsen, 1998). The whiteness index (WI) values of cookies were calculated for 6 cookies per batch as described by Hsu et al., (2003) as follows;

$$100 - \sqrt{(100 - L^*)^2 + a^{*2} + b^{*2}}$$

3. RESULTS AND DISCUSSION

3.1 Proximate composition

The proximate composition of sorghum biscuit enriched with defatted soy flour is shown on Table 2. The moisture content ranged from 3.2- 6.1%. It is comparable to values (5 –10%) set by the protein Advisory Group (FAO/WHO (1971). These values were within the range reported by Kure et al., (1998) as not having adverse effect on the quality attributes of the product. Sanni et al., (2006) reported that the lower the moisture contents of a product, the better the shelf stability of such product. Hence, low moisture ensures higher shelf stability in dried products. However, low residual moisture content in confectionaries is advantageous; resulting in a reduction in microbial proliferation and prolonged storage life if stored inside appropriate packaging materials under good environmental condition. The ash content (Table 2) of the biscuits ranged from 2.3 – 3.5%, the high ash content of SD1 and SD2 might be attributed to their high soy flour content, soybean flour had been reported to be a good source of minerals (Emmanuel – Ikpeme et al., 2012). The ash content of a food material could be used as an index of minerals constituents of the food because ash is the inorganic residue remaining after the water and organic matter have been removed by heating in the present of an

oxidizing agent (Sanni et al., 2008). Crude fat content (Table 2) of the biscuit ranges from 12.0-18.1 %, high fat content was observed in SD1, SD2 and SD3. The fat content of biscuits was relatively low. Fat plays a role in determine the shelf-life of foods. A high amount of fat can accelerate spoilage by promoting rancidity leading to the production of off flavours and odours. Also diet high in fat predispose consumer to different illness such as obesity and heart disease etc. Therefore, low fat content observed in the biscuits is desirable to both the processor and health conscious individual. Crude fiber content (Table 2) of biscuit ranged from 2.0 – 3.8%, high fiber values were obtained in SD4, SD5, SD6 and SD7, and this might be attributed to the high level of sorghum compared to soy flour. These values are favourably compared to the recommended value of 5% (FAO/WHO (1971). Crude protein ranged from 7.3 – 11.3%. SD1, SD2 and SD3 had significantly higher ($P=.05$) protein content than SD4, SD5, SD6 and SD7, the increase in the protein could be due to the increase in the proportion of soy flour added. The carbohydrate content ranged from 58.2 – 70.6 %, significant increase ($P = .05$) was observed in carbohydrate with corresponding decrease in the proportion of defatted soy flour added. The calculated energy value of biscuits ranged from 1825.8 – 2026.1KJ/100g. Energy is not a nutrient but is required in the body for metabolic processes, physiological functions, muscular activity, heat production, growth and synthesis of new tissues. It is released from food components by oxidation. The main sources of energy are carbohydrates, proteins, fats and, to a lesser degree, alcohol. The energy values obtained falls within the recommended value for estimated energy intake of children of age range 1-24 months which is 2000 – 4,800Kj/ day (FNB:IOM 2002); recommended daily energy intake varies with height and age.

Table 2: Proximate composition of sorghum biscuit enrich with defatted soy flour

Moisture (%)	Ash (%)	Crude Fat (%)	Crude Fibre (%)	Crude Protein (%)	Carbohydrate (%)	Energy value (Kj/100g)
6.1 ^a ± 0.0	3.5 ^a ± 0.0	18.0 ^a ± 0.2	2.7 ^d ± 0.1	11.2 ^a ± 0.0	58.2 ^f ± 0.2	1835.0
5.7 ^b ± 0.0	3.0 ^b ± 0.1	18.1 ^a ± 0.1	2.3 ^e ± 0.0	11.0 ^b ± 0.1	59.9 ^e ± 0.4	1866.4
4.8 ^d ± 0.0	2.4 ^d ± 0.1	17.2 ^b ± 0.2	2.0 ^f ± 0.0	11.3 ^a ± 0.1	62.3 ^d ± 0.5	1877.7
4.4 ^e ± 0.0	2.7 ^c ± 0.0	15.8 ^c ± 0.1	3.5 ^b ± 0.1	7.5 ^{de} ± 0.1	66.1 ^b ± 0.3	1825.8
3.2 ^g ± 0.0	2.3 ^d ± 0.1	16.9 ^b ± 0.1	3.4 ^c ± 0.0	7.3 ^e ± 0.2	66.9 ^b ± 0.3	1876.4
5.5 ^c ± 0.0	2.7 ^c ± 0.1	14.6 ^d ± 0.1	3.8 ^a ± 0.0	7.9 ^c ± 0.2	65.5 ^c ± 0.4	2026.1
4.0 ^f ± 0.0	2.5 ^d ± 0.1	12.0 ^e ± 0.2	3.3 ^c ± 0.0	7.6 ^d ± 0.1	70.6 ^a ± 0.1	1992.2

Mean ± standard deviation of three replicates, mean value having different superscript within the same column are significantly different ($P= .05$).

Keys:

138 SD1= 70:30
 139 SD2=77.50: 22.5
 140 SD3= 85:15
 141 SD4= 87.50:12.50
 142 SD5=90:10
 143 SD6=95:5
 144 SD7=92.50:7.50
 145

146 **3.2 Mineral composition**

147 Table 3 shows the Mineral composition of sorghum biscuit enriched with defatted soy flour. Na is regarded as
 148 the most abundant mineral in the biscuit ranges from 91.1 – 119.1mg/100g followed by K (61.3 –
 149 99.4mg/100g). High amount of K in the body was reported to increase iron utilization (Adeyeye 2002), and it is
 150 beneficial to people taking diuretics to control hypertension and suffering from excessive excretion of
 151 potassium through the body fluid (Arinathan et al., 2003). Both sodium and potassium are required to maintain
 152 osmotic balance of the body fluids, the pH of the body, to regulate muscle and nerve irritability, control glucose
 153 absorption, and enhance normal retention of protein during growth (NRC, 1989). The ratio of sodium:
 154 potassium (Na: K) in the body is of great concern for the prevention of high blood pressure. A Na: K ratio of 1 is
 155 recommended (NRC, 1989), values obtained from biscuits are fairly comparable. Cu ranged from 0.03 –
 156 0.17while Zn, ranges from 0.1 – 0.2 mg/100g. Copper and Zinc are two trace minerals essential for important
 157 biochemical functions and necessary for maintaining health throughout life. The respective recommendations
 158 for Zn are 15 mg for men and 12 mg for women (Food and Nutrition Board 1989). The estimated safe and
 159 adequate daily dietary intake (ESADDI) for Cu is 1.5–3.0 mg/d (Food and Nutrition Board 1989), the biscuit
 160 could therefore not be taking as a good source of these minerals, and other dietary sources must be taking so
 161 as to meet the daily requirements. However, Zn:Cu ratios > 16 have been associated with increased risk of
 162 cardiac abnormalities (Klevay et al. 1984, Sandstead 1995). Zn:Cu obtained in the study ranged from 1.2 –
 163 3.3, this implies that the biscuit might reduce the risk of cardiac abnormalities. The Fe content ranged from 1.1
 164 – 1.3 mg/100g. Fe content is lower than the recommended daily allowance (RDA) 10 mg of iron per day (Food
 165 and Nutrition Board 1989), the biscuit is therefore not a good source of iron. Iron is a major component of
 166 hemoglobin that carries oxygen to all parts of the body. Iron also has a critical role within cells assisting in
 167 oxygen utilization, enzymatic systems, especially for neural development, and overall cell function everywhere
 168 in the body. The Ca ranged from 9.5 – 13.8 mg/100g and the Mg ranged from 3.9 – 5.4 mg/100g. Without

magnesium, calcium may be not fully utilized, and underabsorption problems may occur leading to arthritis, osteoporosis, menstrual cramps, and some premenstrual symptoms. The mineral values follow the following order Na>K>Ca>Mg>Fe>Cu>Zn.

Table 3 Mineral compositions of sorghum biscuit enriched with defatted soy flour (mg/100g)

biscuits	K	Na	Na:K	Cu	Zn	Zn:Cu	Fe	Ca	Mg
SD1	99.4 ± 0.0	119.1 ± 0.0	1.2	0.06 ± 0.0	0.2 ± 0.0	3.0	1.3 ± 0.0	17.2 ± 0.0	5.4 ± 0.0
SD2	84.7 ± 0.0	85.9 ± 0.0	1.0	0.03 ± 0.0	0.1 ± 0.0	3.3	1.2 ± 0.0	14.1 ± 0.0	5.2 ± 0.0
SD3	72.9 ± 0.0	99.1 ± 0.0	1.4	0.04 ± 0.0	0.1 ± 0.0	2.5	1.1 ± 0.0	11.9 ± 0.0	4.7 ± 0.0
SD4	74.4 ± 0.0	105.6 ± 0.0	1.4	0.04 ± 0.0	0.1 ± 0.0	2.5	1.2 ± 0.0	12.3 ± 0.0	4.2 ± 0.0
SD5	71.1 ± 0.0	104.4 ± 0.0	1.5	0.05 ± 0.0	0.1 ± 0.0	2.0	1.4 ± 0.0	10.0 ± 0.0	5.3 ± 0.0
SD6	71.9 ± 0.0	97.6 ± 0.0	1.4	0.05 ± 0.0	0.1 ± 0.0	2.0	1.4 ± 0.0	10.4 ± 0.0	5.1 ± 0.0
SD7	61.3 ± 0.0	91.1 ± 0.0	1.5	0.17 ± 0.0	0.2 ± 0.0	1.2	1.3 ± 0.0	9.5 ± 0.0	3.9 ± 0.0

Values are mean ± SD of 3 replicates.

Keys:

SD1= 70:30

SD2=77.50: 22.5

SD3= 85:15

SD4= 87.50:12.50

SD5=90:10

SD6=95:5

SD7=92.50:7.50

3.3 Physical Characteristics of biscuits

Significant differences ($P = .05$) were observed in the diameter, weight, and spread ratio of sorghum biscuits enriched with soy flour. No significant difference was observed ($P = .05$) in the thickness of the biscuits. The diameter ranged from 4.50 – 5.80cm, the least diameter was observed in SD5, SD6 and SD7 respectively., while the least weight (8.27) was observed in SD7, which might be attributed to the high residual fat content of defatted soy flour content of SD1; as fat is lighter in weight; these weight is comparable with the results obtained for bambara groundnut-maize flour (Akpapunam, 1994), cowpea–wheat flour (Okaka and Isieh, 1990), millet-sesame flour (Alobo, 2001) and amaranth - wheat flour (Ayo, 2001). Spread ratio of biscuits ranged from 5.33 – 8.92 cm. Biscuits having higher spread ratios are considered the most desirable (Kirssell and Prentice 1979), SD1 is therefore considered as the most desirable. This is similar to the findings of Mridula, et al., (2007) that spread ratio increase significantly ($P=.05$) with increase in the fat content of the biscuit. There is a relationship between the spread – ability, height, thickness and the breaking strength. The thinner the biscuit, the lesser its ability to withstand stress/load.

Table 4: physical properties of sorghum biscuit enriched with defatted soy flour

Sample	Diameter (cm)	Weight (g)	Thickness (cm)	Spread ratio	Breaking strength (N)
SD1	5.80 ^a ±0.14	8.60 ^f ±0.28	0.65 ^a ±0.01	8.92 ^a ±0.3	1.4

SD2	5.50 ^b ±0.14	8.90 ^{bc} ±0.14	0.62 ^a ±0.01	8.83 ^a ±0.4	1.8
SD3	5.50 ^b ±0.14	8.40 ^d ±0.66	0.81 ^a ±0.03	6.80 ^b ±0.8	2.6
SD4	4.80 ^c ±0.14	8.80 ^{de} ±0.14	0.73 ^a ±0.03	6.58 ^d ±0.3	2.0
SD5	4.50 ^d ±0.28	8.60 ^e ±0.28	0.66 ^a ±0.03	6.80 ^b ±0.7	1.6
SD6	4.50 ^d ±0.14	8.44 ^a ±0.01	0.68 ^a ±0.03	6.62 ^c ±0.3	1.7
SD7	4.50 ^d ±0.28	8.27 ^b ±0.03	0.84 ^a ±0.06	5.33 ^e ±0.4	2.7

Mean ± standard deviation of three replicates, mean value having different superscript within the same column are significantly different (P= .05).

Keys:

SD1= 70:30

SD2=77.50: 22.5

SD3= 85:15

SD4= 87.50:12.50

SD5=90:10

SD6=95:5

SD7=92.50:7.50

3.4 Colour of biscuits

The colour of sorghum biscuits enriched with soy flour is shown Table 5. The L*, a*, b* are not significantly different (P =.05) from each other. L* value ranged from 49.45 – 65.25, a* ranged from 4.70 – 8.30, while b* ranged from 11.09 – 22.47, the variation in the level of defatted soy flour added seems not to have any significant effect (P= .05) on the lightness, chromaticity on a green (-) to red (+) axis, and chromaticity on a blue (-) to yellow (+) axis of the biscuit. Food product colour is a very important characteristics which influences the consumer acceptability.

Table 5: Colour characteristics of sorghum-soy flour biscuit

Biscuits	L*	a*	b*	Hue	Chroma	Whiteness index
SD1	61.46 ^{ab} ±6.39	7.05±0.76	17.24 ^b ±3.00	67.76	18.63	57.20
SD2	56.55 ^{ab} ±6.23	4.73±1.36	11.09 ^b ±0.81	66.90	12.06	54.91
SD3	49.45 ^b ±8.18	6.69±4.78	15.07 ^b ±3.28	66.06	16.49	46.83
SD4	53.98 ^{ab} ±2.81	8.17±0.38	15.99 ^{ab} ±2.04	62.94	17.96	50.60
SD5	56.86 ^{ab} ±7.33	7.17±1.22	15.90 ^{ab} ±4.91	65.73	17.44	53.47
SD6	65.25 ^a ±6.49	4.70±0.01	17.21 ^{ab} ±2.27	74.73	17.86	58.25
SD7	62.78 ^a ±2.83	8.30±0.50	22.47 ^{ab} ±5.42	69.73	23.96	55.73

Mean ± standard deviation of three replicates, mean value having different superscript within the same column are significantly different (P= .05).

Keys:

SD1= 70.00: 30.00

SD2=77.50: 22.50

SD3= 85.00:15.00

SD4= 87.50:12.50

SD5=90.00:10.00

SD6=85.00:15.00

227 SD7=92.50:7.50
228

229 **4. Conclusion**

230 The suitability of sorghum – defatted soy flour in the production of biscuit in combating Protein Energy
231 Malnutrition at the various ratios was shown. The ratios used in the study met the recommended daily intake
232 for the different nutrient considered in the study. The physical parameters of biscuits were not significantly
233 different from each other. The use of sorghum – defatted soy flour could therefore be an affordable way of
234 reducing PEM in sub-Saharan Africa.

235

COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

Author OSO designed the study, managed the literature searches, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. 'AuthorAO managed the analyses of the study. All authors read and approved the final manuscript.

REFERENCES

Adeyeye, E. I (2002) "Determination Of The Chemical Composition Of The Nutritionally Valuable Parts Of Male And Female Common West African Fresh Water Crab *Sudananautes Africanus*," International Journal Of Food Sciences And Nutrition 53 (3) :189–196

Akpanunam M.A and Darbe J. W (1999). Chemical Composition and Functional Properties Of Blend Of Maize Barbara Groundnuts Flours For Cookie Production. Plants Food For Human Nutri., 46:147 -155.

AOAC (2005). Official Methods Of Analytical Chemists, Washington DC.

Arinathan, V. Mohan, V. R., and De Britto, A. J.,(2003) "Chemical Composition of Certain Tribal Pulses In South India," International Journal Of Food Sciences And Nutrition 54(3): 209–217.

Ayo J.A (2001). The Effect Of Amaranth Grain flour on The Quality of Bread. International Journal of food Properties 4(2): 341 –352.

Ayo J. A, Ayo V.A., Nkama I and Adewori R (2007). Physicochemical, In-Vitro Digestibility And Organoleptic Evaluation Of "Acha" Wheat Biscuit Supplementation With Soybean Flour. Nigeria Food Journal 25: 77-89.

Bheema, R.N., Bhabani, S.J. and Pichan, P. (2008). Influence of Natural Antioxidants and Their Carry-Through Property In Biscuit Processing. Journal of Science Food Agriculture, 89, 288–298.

Dendy, D.A.V. (1995). Sorghum And Millets: Chemistry And Technology Published By The American Association Of Cereal Chemists, Inc., St. Paul, Minnesota, USA.

Emmanuel- Ikpeme C. A., Ekpeyoung I. O. and Igile, G.O (2012). Nutritional And Sensory Characteristics of an Infant Food Based On Soybean Seeds (Glycine Max) And Tigernut Tubers (Cyperus Esculenta) British Journal Of Applied Science & Technology 2(4): 356-366.

FAO(2011) Faostat. In [Http://Faostat.Fao.Org/Site/291/Default.aspx](http://Faostat.Fao.Org/Site/291/Default.aspx), Food and Agriculture Organization

FAO/WHO (1971). Protein Advisory Group (PAG) Of The United Nations. Pag Guideline No 8. Protein – Rich Mixtures for use as Weaning Food., New York: FAO / WHO/ UNICEF.

Food and Nutrition Board (1989) Menkes' Kinky-Hair Syndrome. Recommended Dietary Allowances 10th Ed. National Academy Press Washington, DC.

Food and Nutrition Board: Institute of Medicine (2002). Dietary Reference Intakes for Energy, Carbohydrates, Fiber, Fat, Fatty Acids, Cholesterol, Protein And Amino Acids. Washington Dc: National Academy Press.

Hsu C., Chenb, W., Wenga, Y.,Tsenga, C (2003) Chemical Composition, Physical Properties, and Antioxidant Activities Of Yam Flours As Affected By Different Drying Methods. Food Chemistry 83: 85–92

Kirssel, L., and M. Prentice. 1979. Protein and Fiber Enrichment Of Cookie Flour With Brewer's Spent Grain. Cereal Chem. 50:261–265.

- 279 Klevay, L. M., Inman, L. & Johnson, L. K. (1984) Increased Cholesterol in Plasma In A Young Man During
280 Experimental Copper Depletion. *Metabolism* 33:1112-1118.
- 281 Kulkarni S.D (1997). Roasted Soybean In Cookies. Influence on Product Quality. *Journal of Food Science*
282 *Technology* 34: 503-505.
- 283 Kure O.A., Bahago E.J., Daniel, E.A (1998). Studies On the Proximate Composition and Effect Of Flour
284 Particle Size On Acceptability Of Biscuit Produced From Blends Of Soybeans and Plantain Flour. *Namida*
285 *Tech-Scope J.*, 3: 17-21.
- 286 Mridula D, Gupta R.K., Manikantan M.R (2007). Effect Of Incorporation Of Sorghum Flour To Wheat Flour On
287 Quality Of Biscuit Fortified With Defatted Soy Flour. *American Journal of Food Technology* 2(5): 428-
288 434.
- 289 National Research Council (1980) Provisional Tables On Zinc Content Of Foods. *Drinking Water and Health* 3
290 National Academy Press Washington, Dc.
- 291 Nielsen, S.S. (1998). Color Analysis. In: *Food Analysis*. 2nd Edition. Aspen Publishers, Inc., Gaithersburg, Md.,
292 U.S.A. Pp. 601-612.
- 293 Nkama,I (1993) Traditional Methods Of Production Of High Protein Energy Foods Fromgrain Legumes In The
294 North –Eastern States Of Nigeria. *Annals. of Borno* 10:138-148.
- 295 Okaka J.C and Isieh M.I (1990) Development And Quality Evaluation Of Cowpea Wheat Biscuits. *Nigeria*
296 *Food Journal* 8:56 – 62.
- 297 Okoye, J.I. Nkwocha, A.C and Ogbonnaya, A.E.(2008). Production, Proximate Composition And Consumer
298 Acceptability Of Biscuits From Wheat/Soybean Flour Blends. *Continental J. Food Science And*
299 *Technology* 2: 6 – 13.
- 300 Olaoye O.A., Onilude, A A., Oladoye, C.O (2007). Breadfruit Flour In Biscuit Making: *African Journal of Food*
301 *Science* : 20-23.
- 302 Rocha, A.M.C.N. and Morais, A.M.M.B.(2003): Shelf Life Of Minimally Processed Apple (Cv. Jonagored)
303 Determined By Color Changes. *Food Control*, 14(1), 13-20.
- 304 Rooney, L.W. Kirleis, A.W. and Murty, D.S. (1986). Traditional Foods From Sorghum Their Production,
305 Evaluation And Nutritional Value. In: *Advances In Cereal Science And Technology*, Vol. 8. Pomeranz, Y.
306 (Ed.). Icrisat, American Association Of Cereal Chemists, St. Paul, Mn, Usa. 317-353.
- 307 Sandstead, H. H. (1995) Requirements And Toxicity Of Essential Trace Elements, Illustrated By Zinc And
308 Copper. *Am. J. Clin. Nutr.* 61(Suppl.):621s-624s.
- 309 Sanni, L.O., A.A. Adebawale and S.O. Tafa, 2006. Proximate, Functional, Pasting And Sensory Qualities Of
310 Instant Yam Flour. A Paper Presented At The 14th ISTRC Symposium, Central Tuber Crops Research
311 Institute, Trivandrum, Kerala State, India.
- 312 Sanni, S.A. Adebawale, A.R.A Olayiwola I.O. and Maziya-Dixon, B. (2008). Chemical Composition And
313 Pasting Properties Of Iron Fortified Maize Flour. *Journal of Food, Agriculture and Environment* 6: 172-
314 175.
- 315 Schofield C, and Ashworth, A (1996). Why Have Mortality Rates For Severe Malnutrition Remained So High?
316 *Bull World Health Organ.* 74(2): 223–229.
- 317 Sharma, S, Sekhon, K.S, and Nagi H.P (1999)Suitability Of Duruni Wheat For Flat Bread Production. *Journal*
318 *Of Food Science and Technology* 30:61-62

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321
322
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