



Physicochemical Properties of Sorghum Biscuits Enriched with Defatted Soy Flour

O. S. Omoba^{1*} and A. Omogbemile¹

¹Department of Food Science and Technology, Federal University of Technology, Akure, Nigeria.

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. Author AO managed the analyses of the study. All authors read and approved the final manuscript.

Research Article

Received 29th March 2013
Accepted 8th July 2013
Published 9th August 2013

ABSTRACT

Aims: To evaluate the physicochemical properties of sorghum biscuits enriched with defatted soy flour, at specified ratios.

Study Design: Two - way ANOVA

Place and Duration of Study: Department of Food Science and Technology, Federal University of Technology, Akure, Nigeria, from January to September, 2012.

Methodology: The sorghum whole grain used was milled into flour (S) to pass a 500 μ m sieve. The defatted soy flour (D) was supplied by Jof – Ideal Industry, Owo, Nigeria. Sorghum flour was blended with defatted soy flour (SD) at the following ratio – 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 (95.00:5.00), and SD7 (92.50:7.50) and blends were used for biscuits production. The following analysis were carried out on the biscuit samples namely - proximate composition, mineral composition, physical characteristics and colour.

Results: Significant differences ($P \leq 0.05$) were observed in the proximate, energy and mineral compositions of the biscuits. The protein content ranged from 7.3 ± 0.2 to $11.2 \pm 0.2\%$; crude fat ranged from 12.0 ± 0.2 to $18.1 \pm 0.1\%$; crude fiber content ranged from 2.0 ± 0.0 to $3.8 \pm 0.0\%$ while the carbohydrate content ranged from 58.2 ± 0.2 to $70.6 \pm 0.1\%$. Results obtained compare favourably with the recommended dietary intake for each nutrient. The calculated energy value ranged from 1825.8 to 2026.1 KJ/100g. The Na:K ranged from 1.0 to 1.5 while the Zn:Cu ranged from 1.2 to 3.0. The diameter of the

*Corresponding author: E-mail: sadefunmi71@gmail.com;

biscuits ranged from 4.50 ± 0.14 to 5.80 ± 0.14 cm; Weight ranged from 8.27 ± 0.03 to 8.90 ± 0.14 g; thickness ranged from 0.62 ± 0.01 to 0.84 ± 0.06 cm. Breaking strength ranged from 1.4 to 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 nutrient. Hence, formulated biscuit 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. It continues to be a major public health problem throughout the developing world, particularly in southern Asia and sub-Saharan Africa [1]. It therefore becomes imperative to encourage the different formulations of cereals – legumes to improve protein intake of the populace of 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 [2]. It is an important staple food in Africa (Nigeria, Sudan, Ethiopia), Asia (India, China), and the drier part of Central and South America [3]. About 40% of the world wide sorghum production is used in human food preparation [4]. Several developing countries have encouraged the initiation of programs to evaluate the possibility of alternative locally available materials as substitutes for wheat flour. Many efforts have been carried out to promote the use of sorghum flour in the preparation of bread, cake, thereby decreasing the cost associated with imported wheat [5]. Enrichment of cereal-based foods with oil seed protein has received considerable attention [6,7,8,9]. Soybean is a legume which contributes significantly towards protein, mineral, fat and B - complex vitamins to meet the needs of people in developing countries. The usefulness of the legumes in developing high protein foods and 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 [10]. Supplementation of cereal flour with inexpensive staples such as legumes/ pulses helps in improving the nutritional quality of cereal products [11].

Biscuits are part of the popular cereals foods, consume in Nigeria. They are ready to eat, convenient and inexpensive food products, containing digestive and dietary principles of vital importance [12]. In Nigeria, snacks consumption is continually growing and there has been increasing reliance on imported wheat [13].

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

2. MATERIALS AND METHODS

Red Sorghum (*Sorghum bicolor*), Simas cooking margarine, Dangote granulated sugar, salts, were purchased from the Central Market [*Oja Oba*] 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 red whole grain sorghum were milled using a laboratory hammer mill (Falling Number 3100, Huddinge, Sweden) fitted with a 500 µm opening screen to give whole grain flour. This was then vacuum-packed (Vacuum packing machine Model 250) in a thick low density polyethylene film and stored at 4°C prior to usage. Sorghum flour was blended with defatted soy flour at the following ratio (Table1).

Table 1. Formulation of flour blends for biscuits production

Blends	Sorghum Flour	Defatted Soy flour
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	95.00	5.00
SD7	92.50	7.50

2.3 Biscuit Preparation

Margarine and sugar were creamed at low speed for 3 minutes, using a Kenwood Chef Food mixer Model A901. Sorghum flour and defatted soy flour were added and mixed with the cream for 2 minutes 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 ±2°C for 20 minutes and cooled for 30 minutes at ambient temperature. Biscuits were vacuum-packed in a thick low density 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 method 922.06 [14]. Carbohydrate content was calculated by difference and calculated energy value (Kcal/100g) was calculated using the Atwater factor [15] and converted to Kj by multiplying values with 4.18.

2.4.1 Mineral determination

Mineral contents of biscuits were determined by Atomic Absorption Spectrometry and flame photometry according to AOAC method 965.09 [16]

2.4.2 Wet digestion of sample

For wet digestion of sample, exactly (1 g) of the grinded biscuit sample was taken in digesting glass tube. Twelve milliliters (12ml) of HNO₃ was added to the biscuit samples and mixture was kept overnight at room temperature. Then, 4.0 ml perchloric acid (HClO₄) was added to this mixture and was kept in the fumes block for digestion. The temperature was increased gradually, starting from 50°C to 250-300°C. The digestion was completed in about 70 - 85 minutes as indicated by the appearance of white fumes. The mixture was left to cool

down and the contents of the tubes were transferred to 100 ml volumetric flasks and the volumes of the contents were made to 100 ml with distilled water. The wet digested solution was transferred to plastic bottles labeled accurately. The digest was stored and used for mineral determination.

2.4.3 Procedure

The digested sample was analyzed for mineral contents by Atomic Absorption Spectrophotometer (Hitachi model 170-10) in the Biochemistry Department of the Federal University of Technology, Akure, Nigeria. Different electrode lamps were used for each mineral. The equipment was run for standard solutions of each mineral before and during determination to check that it is working properly. The dilution factor for all minerals except Mg was 100. For determination of Mg, further dilution of the original solution was done by using 0.5 ml of the original solution and enough distilled water was added to make the volume up to 100 ml. Also for the determination of Ca, 1.0 ml lithium oxide solution was added to the original solution to unmask Ca from Mg. The concentrations of minerals recorded in parts per million [ppm] were converted to milligrams [mg] of the minerals. This was achieved by multiplying the ppm with dilution factor and dividing by 1000, as follows:

$$MW = \text{Absorbency (ppm)} \times \text{dry wt.} \times D/Wt. \text{ of sample} \times 1000$$

Note: Dilution factor for magnesium is 10000 and for other minerals including calcium, iron, zinc and sodium is 100

2.4.4 Determination of sodium (Na) and potassium (K) by flame photometer

Na and K contents were determined using flame photometer (Sherwood Flame Photometer 410, Sherwood Scientific Ltd. Cambridge, UK).

2.4.5 Principle

The flame photometer measures the emission of radiant energy when atoms of an element return to their ground state after their excitation by the high temperature of the flame. The degree of emission is related to the concentration of the element in the solution.

2.4.6 Procedure

Na and K analysis of the sample were done by flame-photometric method. The same wet digested food sample solutions as used in AAS were used for the determination of Na and K. Standard solutions of 20, 40, 60, 80 and 100 milliequivalent/l were used both for Na and K. The calculations for the total mineral intake involve the same procedure as given in AAS.

2.5 Physical Characteristics of Biscuits

The weight and the diameter of the baked biscuits were determined by weighing balance and measuring with a calibrated ruler, respectively [17]. Thickness and spread ratio of biscuits were calculated using the AACC method 10 – 50D [18]. Spread ratio was calculated as the ratio of the biscuit diameter to thickness after baking. The breaking strength was determined using an Instron Texture Analyzer according to the method described by Bheema et al., [19].

2.5.1 Determination of colour

The colour of the biscuits was measured according to the method described by Rocha and Morais [20], with a hand held tristimulus reflectance colorimeter. 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 [21]. 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 [22]. 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* [23]. The Whiteness Index (WI) values of cookies were calculated for 6 cookies per batch as described by Hsu et al., [24] as follows;

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

2.5.2 Statistical analysis

All determinations were performed in triplicate and results were expressed as mean values ± standard deviations (SD). Data were subjected to statistical analysis using SPSS software version 15.0.1. Two – way analysis of variance (SPSS Inc., Chicago, IL, USA) followed by Duncan's multiple range test [25] were employed and the differences between means were deemed to be significant at $P \leq 0.05$.

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 [26]. These values were within the range reported as not having adverse effect on the quality attributes of the product [27]. The lower the moisture contents of a product, the better the shelf stability of such product [28]. 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 [29]. The ash content of a food material could be used as an index of minerals constituents of the food. This is because ash is the inorganic residue remaining after the water and organic matter have been removed by heating in the presence of an oxidizing agent [30]. Crude fat contents (Table 2) of the biscuits ranged from 12.0-18.1 %. The fat content of biscuits was relatively low. Fat plays a role in determine the shelf-life of foods. A high amount of fat could accelerate spoilage by promoting rancidity which could lead to the production of off flavours and odours. Also diet high in fat predispose consumer to different illness such as obesity, heart disease, etc. The Crude fiber content (Table 2) of the biscuits 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 favourably agree with the

recommended value of 5% [24]. Crude protein ranged from 7.3 – 11.3%. SD1, SD2 and SD3 had significantly higher ($P \leq 0.05$) 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 ($P \leq 0.05$) 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. These values were significantly different from each other, since calculated energy value of a food is based on its chemical composition, which differs in these respects. 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 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 [31]. The recommended daily energy intake varies with height and age.

3.2 Mineral Composition

Table 3 shows the mineral composition of sorghum biscuit enriched with defatted soy flour. Na is regarded as the most abundant mineral in the biscuit and ranged from 91.1 to 119.1mg/100g, followed by K (61.3 – 99.4mg/100g). High amount of K in the body was reported to increase iron utilization [32]. This is beneficial to people taking diuretics to control hypertension and suffering from excessive excretion of potassium through the body fluid [33]. Both sodium and potassium are required to maintain osmotic balance of the body fluids, the pH of the body, to regulate muscle and nerve irritability, control glucose absorption, and enhance normal retention of protein during growth [34]. The ratio of sodium: potassium (Na: K) in the body is of great concern for the prevention of high blood pressure. A Na: K ratio of 1 is recommended [35]. The values obtained from the biscuits are fairly comparable. Cu ranged from 0.03 – 0.17 while Zn ranged from 0.1 – 0.2 mg/100g. Copper and Zinc are two trace minerals essential for important biochemical functions and necessary for maintaining health throughout life. The recommendations for Zn are 15 mg for men and 12 mg for women [36]. The estimated safe and adequate daily dietary intake (ESADDI) for Cu is 1.5– 3.0 mg/d [35]. The biscuit could therefore not be taken as a good source of these trace minerals. This implies that other dietary sources must be explored to meet the daily requirements. However, Zn:Cu ratios >16 have been associated with increased risk of cardiac abnormalities [37]. Zn:Cu obtained in the study ranged from 1.2 – 3.3. This implies that the biscuits might reduce the risk of cardiac abnormalities. The Fe content ranged from 1.1 – 1.3 mg/100g. Fe content is lower than the recommended daily allowance (RDA) - 10 mg of iron per day [35]. These biscuits are therefore not a good source of iron. Iron is a major component of hemoglobin that carries oxygen to all parts of the body. Iron also has a critical role within cells assisting in oxygen utilization, enzymatic systems, especially for neural development, and overall cell function everywhere in the body. Ca content ranged from 9.5 – 13.8 mg/100g and Mg ranged from 3.9 – 5.4 mg/100g. Without magnesium, calcium may not be fully utilized, and under-absorption problems may occur resulting in arthritis, osteoporosis, menstrual cramps, and some premenstrual symptoms. The mineral values follow the following order Na>K>Ca>Mg>Fe>Cu>Zn.

Table 2. Proximate composition of sorghum biscuit enriched with defatted soy flour

Biscuits	Moisture (%)	Ash (%)	Crude Fat (%)	Crude Fibre (%)	Crude Protein (%)	Carbohydrate (%)	Energy value (Kj/100g)
SD1	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 ^f ± 0.0
SD2	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 ^e ± 0.0
SD3	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 ^c ± 0.0
SD4	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 ^g ± 0.0
SD5	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 ^d ± 0.0
SD6	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 ^a ± 0.0
SD7	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 ^b ± 0.0

Mean ± standard deviation of three replicates; mean values having different superscript within the same column are significantly different ($P \leq 0.05$)

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 ^a ± 0.0	119.1 ^a ± 0.0	1.2	0.06 ^b ± 0.0	0.2 ^a ± 0.0	3.0	1.3 ^b ± 0.0	17.2 ^a ± 0.0	5.4 ^a ± 0.0
SD2	84.7 ^b ± 0.0	85.9 ^g ± 0.0	1.0	0.03 ^e ± 0.0	0.1 ^b ± 0.0	3.3	1.2 ^c ± 0.0	14.1 ^b ± 0.0	5.2 ^c ± 0.0
SD3	72.9 ^d ± 0.0	99.1 ^d ± 0.0	1.4	0.04 ^d ± 0.0	0.1 ^b ± 0.0	2.5	1.1 ^d ± 0.0	11.9 ^d ± 0.0	4.7 ^e ± 0.0
SD4	74.4 ^c ± 0.0	105.6 ^b ± 0.0	1.4	0.04 ^d ± 0.0	0.1 ^b ± 0.0	2.5	1.2 ^c ± 0.0	12.0 ^c ± 0.0	4.2 ^f ± 0.0
SD5	71.1 ^e ± 0.0	104.4 ^c ± 0.0	1.5	0.05 ^c ± 0.0	0.1 ^b ± 0.0	2.0	1.4 ^a ± 0.0	10.0 ^e ± 0.0	5.3 ^b ± 0.0
SD6	71.9 ^e ± 0.0	97.6 ^e ± 0.0	1.4	0.05 ^c ± 0.0	0.1 ^b ± 0.0	2.0	1.4 ^a ± 0.0	10.4 ^e ± 0.0	5.1 ^d ± 0.0
SD7	61.3 ^f ± 0.0	91.1 ^f ± 0.0	1.5	0.17 ^a ± 0.0	0.2 ^a ± 0.0	1.2	1.3 ^b ± 0.0	9.5 ^f ± 0.0	3.9 ^g ± 0.0

Mean ± standard deviation of three replicates; mean values having different superscript within the same column are significantly different ($P \leq 0.05$)

3.3 Physical Characteristics of Biscuits

Table 4 shows the physical properties sorghum biscuits enriched with defatted soy flour. Significant differences ($P \leq 0.05$) were observed in the diameter, weight, and spread ratio of sorghum biscuits enriched with soy flour. No significant difference was observed ($P \leq 0.05$) in the thickness of the biscuits. The diameter ranged from 4.50 to 5.80cm. The least diameter was observed in SD5, SD6 and SD7 respectively. 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 SD7. This is because fat is lighter in weight. These weights are comparable with the results obtained for cowpea–wheat flour [7], millet-sesame flour [8], amaranth - wheat flour [9] and bambara groundnut-maize flour [13]. Spread ratio of the biscuits ranged from 5.33 to 8.92 cm. Biscuits having higher spread ratios are considered the most desirable [36]. SD1 is therefore considered as the most desirable. The spread ratio increase significantly ($P \leq 0.05$) with increase in the fat content of the biscuits. Spread ratio could have been affected by the competition of ingredients for the available water and other functional properties of proteins and fat. Invariably, this might affect the texture and eating quality of the biscuits. There is a relationship between the spread – ability, height, thickness and the breaking strength of the differently enriched biscuits, the thinner the biscuit the lesser its ability to withstand stress/load.

Table 4. Physical properties of sorghum biscuits 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 ^g ±0.01
SD2	5.50 ^b ±0.14	8.90 ^{bc} ±0.14	0.62 ^a ±0.01	8.83 ^a ±0.4	1.8 ^d ±0.01
SD3	5.50 ^b ±0.14	8.40 ^d ±0.66	0.81 ^a ±0.03	6.80 ^b ±0.8	2.6 ^b ±0.01
SD4	4.80 ^c ±0.14	8.80 ^{de} ±0.14	0.73 ^a ±0.03	6.58 ^d ±0.3	2.0 ^c ±0.01
SD5	4.50 ^d ±0.28	8.60 ^e ±0.28	0.66 ^a ±0.03	6.80 ^b ±0.7	1.6 ^f ±0.01
SD6	4.50 ^d ±0.14	8.44 ^a ±0.01	0.68 ^a ±0.03	6.62 ^c ±0.3	1.7 ^e ±0.01
SD7	4.50 ^d ±0.28	8.27 ^b ±0.03	0.84 ^a ±0.06	5.33 ^e ±0.4	2.7 ^a ±0.01

Mean ± standard deviation of three replicates, mean values having different superscript within the same column are significantly different ($P \leq 0.05$)

3.4 Colour of Biscuits

The colour of the sorghum biscuits enriched with soy flour is shown in Table 5. The L*, a*, and b* values are not significantly different ($P \leq 0.05$) from one another. L* value ranged from 49.45 to 65.25, a* ranged from 4.70 to 8.30, while b* ranged from 11.09 to 22.47. The variation in the level of defatted soy flour added seems not to have any significant effect ($P \leq 0.05$) on the lightness, chromaticity on a green (-) to red (+) axis, and chromaticity on a blue (-) to yellow (+) axis of the biscuits. Food products colour is a very important characteristic which influences the consumer acceptability.

Table 5. Colour characteristics of sorghum-soy flour biscuits

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

Mean ± standard deviation of three replicates, mean values having different superscript within the same column are significantly different (P ≤ 0.05)

4. CONCLUSION

The suitability of sorghum – defatted soy flour at the various ratios in the production of biscuits with improved nutritional characteristics was shown. Increase in the protein and mineral compositions of the biscuits were observed to meet daily dietary requirement, especially for children. Biscuits with desirable spread ratio were produced. No significant difference was observed in the colour characteristics of the biscuits.

COMPETING INTEREST

Authors have declared that no competing interests exist.

REFERENCES

1. Schofield C, Ashworth A. Why Have Mortality Rates For Severe Malnutrition Remained So High? Bulletin of World Health Organization. 1996;74:223–9.
2. FAO Faostat. In available: <http://Faostat.Fao.Org/Site/291/Default.aspx>, Food and Agriculture Organization 2011.
3. Dendy DAV. Sorghum and Millets: chemistry and technology Published By The American Association of Cereal Chemists, Inc., St. Paul, Minnesota, USA; 1995.
4. Rooney LW, Kirleis AW, Murty DS. Traditional foods from sorghum their production, evaluation and nutritional value. In: Advances in Cereal Science and Technology, Vol. 8. Pomeranz, Y. (Ed.). Icrisat, American Association of Cereal Chemists, St. Paul, Minneapolis, USA. 1986;317-53.
5. Olaoye OA, Onilude AA, Oladoye, CO. Breadfruit flour in biscuit making: Effects on product quality. African Journal of Food Science. 2008;1:20-3.
6. Fasasi OS, Oyeboode ET, Olusanya D. Proximate and functional properties of modified Bambara isolate - "ogi" mix as complimentary diet. Journal of Sustainable Technology, 2011;2(1):127-33.
7. Okaka JC, Isieh MI. Development and quality evaluation of cowpea wheat biscuits. Nigeria Food Journal. 1990;8:56–62.
8. Aloba AP. Effect of sesame seed flour on millet biscuit characteristics. Plant Food Human Nutrition. 2001;56:195–200.
9. Ayo JA. The effect of amaranth grain flour on the quality of bread. International Journal of Food Properties. 2001;4(2):341–52.

10. Nkama I. Traditional methods of production of high protein energy foods from grain legumes in the North –Eastern States of Nigeria. *Annals of Borno*. 1993;10:138-48.
11. Sharma S, Sekhon KS, Nagi HP. Suitability of Duruni wheat for flat bread production. *Journal of Food Science and Technology*. 1999;30:61-2.
12. Kulkarni SD. Roasted soybean in cookies. Influence on product quality. *Journal of Food Science Technology*. 1997;34:503-5.
13. Akpapunam MA, Darbe JW. Chemical composition and functional properties of blend of maize bambara groundnuts flours for cookie production. *Plants Food Human Nutrition*. 1994;46:147-55.
14. AOAC International. Official Methods of Analysis of AOAC International, 16th ed. The Association, Arlington, X.A; 1995.
15. Okoye JI, Nkwocha AC, Ogbonnaya AE. Production, proximate composition and consumer acceptability of biscuits from wheat/soybean flour blends. *Continental Journal of Food Science and Technology*. 2008;2:6–13.
16. Ayo JA, Ayo VA, Nkama I, Adewori R. Physicochemical, in-Vitro digestibility and organoleptic evaluation of “Acha” wheat biscuit supplementation with soybean flour. *Nigeria Food Journal*. 2007;25:77-89.
17. AACC. American Association of Cereal Chemists. Approved Methods. 10th Edition; 2000.
18. Bheema RN, Bhabani SJ, Pichan P. Influence of natural antioxidants and their carry-through property in biscuit processing. *Journal of Science Food Agriculture*. 2008;89:288–98.
19. Rocha AMCN, Morais AMMB. Shelf life of minimally processed apple (*Cv. Jonagored*) determined by color changes. *Food Control*. 2003;14(1):13-20.
20. Francis FJ. Colour quality evaluation of horticultural crops. *Horticultural Science*. 1980;15:58–9.
21. Nielsen SS. Color Analysis. In: *Food Analysis*. 2nd Edition. Aspen Publishers, Inc., Gaithersburg, Md., U.S.A. 1998;601-12.
22. Hsu C, Chenb W, Wenga Y, Tsenga C. Chemical composition, physical properties, and antioxidant activities of yam flours as affected by different drying methods. *Food Chemistry*. 2003;83:85–92
23. FAO/WHO Protein Advisory Group (PAG) Of The United Nations. Protein – Rich Mixtures for use as Weaning Food., New York: FAO / WHO/ UNICEF. 1971;8.
24. Kure OA, Bahago EJ, Daniel EA. Studies on the proximate composition and effect of flour particle size on acceptability of biscuit produced from blends of soybeans and plantain flour. *Namida Tech-Scope Journal*. 1998;3:17-21.
25. Duncan DB. Multiple ranges and multiple f test. *Biometrics*. 1995;11:1–42.
26. Sanni LO, Adebawale AA, Tafa SO. Proximate, functional, pasting and sensory qualities of instant yam flour. A paper presented at the 14th ISTRC symposium, Central Tuber Crops Research Institute, Trivandrum, Kerala State, India; 2006.
27. Emmanuel- Ikpeme CA, Ekpeyoung IO, Igile GO. Nutritional and sensory characteristics of an Infant food based on soybean seeds (*Glycine max*) and tigernut tubers (*Cyperus esculenta*). *British Journal of Applied Science and Technology*. 2012;2(4):356-66.
28. Sanni SA, Adebawale ARA, Olayiwola IO, Maziya-Dixon, B. Chemical composition and pasting properties of iron fortified maize flour. *Journal of Food, Agriculture and Environment*. 2008;6:172-75.
29. Food and Nutrition Board: Institute of medicine. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids (macronutrients). Washington, DC: National academy press; 2002.

30. Adeyeye EI. Determination of the chemical composition of the nutritionally valuable parts of male and female common West African fresh water crab '*Sudanautes Africanus*'. International Journal of Food Sciences and Nutrition. 2002;53(3):189–96.
31. Arinathan V. Mohan VR, De Britto AJ. Chemical composition of certain tribal pulses In South India. International Journal of Food Sciences and Nutrition. 2003;54(3):209–17.
32. NRC National Research Council, provisional tables on zinc content of foods. Drinking water and health 3. National Academy press Washington, DC; 1980.
33. NRC. National Research Council, Food and Nutrition Board. Recommended Dietary Allowances, 10th ed. Washington, D.C. National Academy of Sciences; 1989.
34. Food and Nutrition Board. Menkes' Kinky – hair syndrome. Recommended dietary allowances 10th ed. National Academy of Sciences; 1989.
35. Sandstead HH. Requirements and toxicity of essential trace elements Illustrated by Zinc and Copper. American Journal of Clinical Nutrition. 1995; 61:621s-24s.
36. Kirssel L, Prentice M. Protein and fiber enrichment of cookie flour with brewer's spent grain. Cereal Chemistry. 1979;50:261–265.
37. Klevay LM, Inman L, Johnson LK. Increased cholesterol in plasma in a young man during experimental copper depletion. Metabolism. 1984; 33: 1112–18.

© 2013 Omoba and Omogbemile; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/3.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here:
<http://www.sciencedomain.org/review-history.php?iid=226&id=5&aid=1842>