Full Length Research Paper

Evaluation of nutritional properties of high protein-fiber based snacks formulated from wheat, soybean concentrate and cassava fiber

OGUNMODIMU, O. Opeoluwa, IJAROTIMI, O. Steve* and FAGBEMI, T. Nathaniel

Department of Food Science and Technology, Federal University of Technology, P. M. B., 704, Akure, Nigeria.

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Functional snacks were produced from soybean concentrate, cassava fibre and wheat flour. Food materials were processed into flour and blended in the ratio of 65:22:13 (SWC1), 75:18:7 (SWC2), 85:13:2 (SWC3) and 75:25:0 (SC). Each sample was mixed with condiments, water, manually extruded, baked, and evaluated for proximate compositions, microbial loads, physical and sensory properties. Results showed that the formulated snacks had crude protein value of 12.43 - 67.0%, ash 2.41 - 5.97%, moisture content 6.89 - 10.43%, crude fat 2.81 - 3.85%, crude fibre 2.77 - 6.09% and carbohydrate 9.35 - 72.68%. Mineral contents (mg/100g), i.e., iron had value of (17.31 - 201.17), Zn (20.30 - 29.87), Mn (3.43 - 7.10), Cu (1.37 - 9.13) and Na (3346.67 - 13466.67). Nickel, lead and Cadmium were not detected. Glutamic acid (23.93-19.83g/100g protein) had the highest values of amino acids, while tryptophan had the least (0.72 - 0.95g/100g protein). Anti-nutritional factors and microbial loads of the snacks were low and within the acceptable level, water absorption capacity of the snacks had value of 1.77 - 2.20%, oil absorption capacity 0.87 - 1.78%, loose bulk density 0.60 - 0.78g/ml, packed bulk density 0.90 - 1.20 g/ml, swelling capacity 0.65 - 0.82% and least gelation concentration 0.60 - 0.77%. Sample SC was most preferred than other samples, but less preferred to control sample (CS). The study concluded that sample SC was preferred to others and comparable to control (CS).

Key words: Functional snacks, nutrient compositions, sensory attributes.

INTRODUCTION

Protein in human diets is obtained from several sources that include plant and animal, but animal sources are regarded as the best because of its balanced amino acid content. However, the cost of animal protein is increasing every day, thus making it unaffordable to many people in developing countries (Cuthbertson, 1970; Ekpo, 2011). Evidences have shown that in many parts of developing countries many families look for alternative source of protein from plant origin like cereal and legumes, because of high cost of animal-based foods, and this constitute large proportions of overall proteins consumed daily (Li, 2013; Adegoke et al., 2014). Diverse efforts have been made to improve the nutritional value of snacks by incorporating protein from plant sources (Alavi et al., 1999; Mathew et al., 1999; Chang et al., 2001; Hashimoto et al., 2002). New technologies have helped to segregate the readily digestible fractions of foods from the non-digestible fractions such as fiber and resistant starches. This has changed the eating habits of many communities that only the digestible fractions are consumed. This gradual shift away from fiber in diets calls for development of food products that would restore the levels of dietary fiber. It is evident that high dietary fiber intake is associated with lower risk of coronary heart disease, diabetes, colon cancers and bowel disorders (Montonen et al., 2003; Lairon et al., 2005; Petruzziello et al., 2006). Snacks such as biscuits and crackers receive less attention than bread; however they offer several important advantages including: wide consumption, relatively long shelf life, good eating quality, highly palatable and acceptable in most countries and can be modified to suit specific nutritional needs of any

*Corresponding author. E-mail: soijarotimi@gmail.com or soijarotimi@futa.edu.ng.
target population. These characteristics make protein rich snacks attractive for target groups especially school feeding programs, emergency-feeding programs and in preventing protein-energy malnutrition among less privileged children. Studies have shown that snacks can be used as a vehicle to increase nutritional status of consumers by incorporating nutrients such as protein and fiber, which have health benefits (Camire and Krumhar, 1990; Zazueta-Morales et al., 2001). The need to consume foods high in protein and fiber but low in sugar to prevent pathological diseases necessitates this research. Therefore, the purpose of the present study was to produce nutritious snacks from soy concentrate, cassava fiber and wheat composite flour.

**MATERIALS AND METHODS**

**Materials**

The cassava spent grain (wet) was obtained from MATNA Foods, Ogbese. The soybean concentrate was processed from defatted soybean cake, which was obtained from JOF Ideal family farm, Owo. Wheat flour (Golden penny) and Chewy snacks were obtained from local market in Akure, Ondo state, Nigeria.

**Processing of flour samples**

**Preparation of wheat flour**

One kilogram of wheat grains was weighed, sorted, oven dried (Galenkamp, size 3, hotbox, London, UK) at 60°C for 20 h, milled in attrition mill (Philips laboratory blender (HR2811 model), sieved through 150 wire mesh and packed in polyethylene nylon and stored at room temperature prior to analysis (Figure 1).

**Preparation of cassava fibre**

Cassava spent grain (wet) was washed, pressed, oven dried at 60°C (Plus11 Sanyo Gallenkamp PLC, UK) for 20 h, milled using Philips laboratory blender (HR2811 model) and sieved using a 60 mm mesh sieve (British Standard) to obtain cassava fiber flour sample. The fiber flour was stored in plastic container at room temperature (~27°C) until required for use (Figure 1).
Preparation of protein concentrates from defatted soybean cake

Defatted soybean flour (1 kg) was dispersed in 10 l (10:1) of distilled water, the pH were adjusted to 8.0 - 9.0 with 1M NaOH to facilitate protein solubilisation, stirred using magnetic stirrer for 4 h. The solution was centrifuged at 4000 x g for 30 min using Baire and Tatlock Autobench Centrifuge, Markic 4. The pH of the supernatant was adjusted to 4.5 with 0.5M HCl, centrifuged at 4000 x g for 30 min. The protein concentrate was washed, neutralized to pH 7 using NaOH, and freeze dried (Lawal and Adebowale, 2004).

Formulation of flour and production of snacks

Linear programming was used to optimize the blending of the flours, i.e., soy concentrate, cassava fibre and wheat with reference to protein and fiber content of the flour samples to obtain the following samples: SWC1 (65.4% soybean concentrate, 21.4% cassava fiber and 13.3% wheat flour), SWC2 (75.4% soybean concentrate, 17.4% cassava fiber and 7.3% wheat flour), SCW3 (85.4% soybean concentrate, 12.4% cassava fiber and 2.3% wheat flour), SC (soy concentrate 75% and cassava fibre 25%) and CS (100% wheat flour). The blended flour (100 g) were weighed into the mixing bowl, salt, sugar and flavouring agent were weighed (10 g) and mixed thoroughly with the flour sample. Water (40 ml) was added and mixed thoroughly to form dough. The dough was manually extruded (cold extrusion) and baked in oven at 100°C for 1 h (Figure 1).

Chemical analyses

Proximate analyses

Moisture content, crude protein, crude fiber, crude fat and ash content of the snacks were determined using the standard procedures of Association of Official Analytical Chemists (AOAC) (2005). Carbohydrate content was determined by difference, that is, addition of all the percentages of moisture, fat, crude protein, ash and crude fibre was subtracted from 100%. This gave the amount of nitrogen free extract otherwise known as carbohydrate.

% carbohydrate = 100-(% Moisture + %Fat + %Ash + %Crude fibre + %Crude protein)

The energy value of the samples were estimated (kcal/g) by multiplying the percentages of crude protein, crude lipid and carbohydrate with the recommended factors (2.44, 8.37 and 3.57 respectively) as proposed by (lombor et al., 2009).

Mineral analyses

Calcium (Ca), magnesium (Mg), iron (Fe), copper (Cu), zinc (Zn) were determined using Atomic Absorption Spectrophotometer (AAS Model SP9). Sodium (Na) and potassium (K) were determined using flame emission photometer (Sherwood Flame Photometer 410, Sherwood Scientific Ltd. Cambridge, UK) with NaCl and KCl as the standards (AOAC 2005). Phosphorus was determined using Vanado-molybdate method. All values were expressed in mg/100g.

Determination of amino acid content of the snack

High-performance liquid chromatography

Analytical (HPLC) system was used to determine the amino acid profiles after samples were hydrolyzed for 24 h with 6 M HCl according to the method previously described by Bidlingmeyer et al. (1984). The cysteine and methionine contents were determined after performic acid oxidation and tryptophan content was measured colorimetrically (Pintér-Szakács and Molnár-Perl, 1990).

Calculated nutritional quality of snacks

Protein efficiency ratio (PER)

Protein efficiency ratio of the snack samples were calculated according to the equations developed by Alsmeyer et al. (1974).

\[ \text{PER} = 0.06320 \times [X_{10}] - 0.1539 \]

Where \( X_{10} \) = Thr + Val + Met + Ile + Leu + Phe + Lys + His + Arg + Tyr

Essential Amino Acid Index (EAAI)

Nutritional qualities were determined on the basis of the amino acid profiles. The Essential Amino Acid Index (EAAI) was calculated using the method of Labuda et al. (1982) according to the equation below:

\[ EAAI = \sqrt{\frac{100a \times 100b \ldots 100j}{av \times bv \ldots jv}} \]

where:
\( n = \) number of essential amino acids, \( a, b \ldots \ldots j \) represent the concentration of essential amino acids (lysine, tryptophan, isoleucine, valine, arginine, threonine, leucine, phenylalanine, histidine and the sum of
methionine and cystine) in test sample and av, bv ..... jv = content of the same amino acids in standard protein (%) (egg or casein) respectively.

**Biological value (BV)**

Biological Values were computed according to the methods of Oser (1959), respectively. The following equation was used for BV determination.

\[ BV = 1.09 \times \text{EAA Index} - 11.7 \]

**Nutritional index (NI)**

The nutritional index of the food samples was calculated using the formula below as described by Crisan and Sands (1978).

\[ \text{Nutritional index} \times \text{%protein} = \frac{\text{EAAI} \times \text{protein}}{100} \]

**Determination of ant-nutritional factors**

Phytates were determined by the anion-exchange method as described by AOAC (2000) using phosphate as the standard. Oxalate content of the food samples was determined using the method of AOAC (2005). Tannin contents were determined by the modified vanillien-HCl methods described by Makkar and Goodchild (1996). Trypsin activity of the samples was determined using the method of Prokopet and Unlenbruck (2002). Total cyanide content was determined using Spectrophotometric method as described by AOAC (1990). Uric acid was analysed using the method described by Harien and Soderstrom (1966).

**Microbiological evaluation**

Aerobic plate count was determined by pour plate method where serial dilution (10^{-1} to 10^{-8}) of the snacks samples was made and aliquots of 1 ml were added to each duplicate Petri dish. Plate count agar was added to each Petri dish and incubated at 35°C for 48 hours, after incubation colony was counted by colony counter and result was expressed as cfu/g. For mould and yeast counts, the above procedure was repeated using potato dextrose agar and incubation was done at 28°C for 3-5 days and expressed as cfu/g (AOAC, 1990).

**Determination of functional properties**

The following functional properties were carried out on the blended flour samples for the production snacks: Bulk density was determined by the modified method of Wang and Kinsella (1976). Water/oil absorption capacity (WAC) an index of the amount of water/oil retained within a food matrix under certain conditions and it was determined using the method of Sathe and Salunkhe (1981) as modified by Adebowale et al., (2005). Swelling index (SI) was determined using the method described by Ukpabi and Ndimele (1990), while least gelation concentration (LGC) was determined using the method described by Coffman and Garcia (1977) as modified by Akubor and Chukwu (1999).

**Physical characteristics of snacks**

The physical characteristics of the snacks were carried out which include the diameter, length, and thickness. Diameter, thickness and length were determined with a pair of Vernier calipers (Mitutoyo Corp., Japan) accurate to 0.05 mm. Diameters were measured with a Vernier caliper on 10 samples and averaged.

**Sensory evaluation**

Sensory evaluation was performed on the snacks using the 9-point Hedonic scale rating as described by Iwe, (2002). Thirty (30) untrained panelists who were familiar with the products were selected and briefed about the aim of the test and evaluation procedures. The panelists were to rate the products with reference to texture, aroma, taste, hardness and overall acceptability, and the rating was from 9 as like extremely and 1 as dislike extremely.

**Statistical analysis**

The results obtained from the various analyses which were at least in triplicates were subjected to Analysis of Variance (ANOVA) using statistical package for social sciences (SPSS) IBM Version 20.0. Duncan multiple range test (DMRT) was used to separate the means.

**RESULTS AND DISCUSSION**

**Proximate and mineral compositions of functional snacks**

**Proximate compositions**

The results of proximate composition of snacks are presented in Table 1. Moisture content of the functional snacks ranged from 9.04% in SC to 10.43% in SWC2 sample, and there was no significant difference (p > 0.05) between the moisture content of the formulated functional snacks. The moisture contents of the formulated snacks were significantly (p < 0.05) higher than in control sample.
(SC). This observation showed that the formulated snacks cannot be stored for a long period when compared with the control sample. Scientific investigations have reported that the amount of moisture content in food products will determine the shelf-life of the products; for instance, low moisture content in foods would reduce the activities of micro-organisms and thereby increased the storage periods of the food products (Noorlidah and Nawawi, 2000; Oligino et al., 2007; Alozie et al., 2009). Protein contents of the functional snacks ranged from 51.09% in SWC1 to 67.0% in SWC3, and these values were significantly higher (p<0.05) than in control sample (CS) (12.43%). The high protein content observed in the snacks of this study could be due to the level of soy protein concentrate that was supplemented into the flour samples during the snack productions. This finding agreed with the report of Kolapo and Sanni (2005). Quality protein intake is a major nutritional problem in many parts of developing countries including Nigeria where cost of animal-based protein is high and not affordable by many less privileged families (Cuthbertson, 1970; Ekpo, 2011). Crude fibre content of functional snacks ranged from 4.08% in SWC3 to 6.09% in SC, and the fiber contents of formulated snacks were significantly higher (p<0.05) when compared with the control sample (CS) (2.77%). This could be attributed to supplementation of cassava fibre into the wheat flour during the production of the snacks. It has been reported that high fiber intake prevents diet related diseases like cardiovascular disease; cancer of the colon and diabetes (Rimm et al., 1996; Pereira and PIns, 2000, Schulze et al., 2004). Scientific study has established that one of the physiological roles of crude fiber in the body is to maintain an internal distention for proper peristaltic movement of the intestinal tract (Oduor et al., 2008), and thereby prevent constipation (Groff et al., 1995). Diets with high fiber content have been used for weight control and fat reduction, it provides satiety and thereby reduces the amount of energy given food that would be consumed (Ekop, 2004). Energy values of the formulated snacks ranged from 332.88 kcal in SC to 342.01 kcal in SWC1 sample, and the values were significantly lower when compared with the control sample (365.73 kcal). The low energy values of these snacks has some nutritional and health benefits, for instance, the regular intakes of these snacks could facilitate weight reduction in overweight/obese individuals or in managing diabetes mellitus.

### Mineral composition of formulated snacks

The mineral compositions of the formulated snacks are presented in Table 2. The mineral contents and ranged values of the minerals were as follows: sodium (3346.67 ± 3.33 - 8466.67 ± 88.19 mg/kg), iron (17.3 ± 0.07 - 201.3 ± 0.09 mg/kg), potassium (1086.67 ± 3.33 - 5350 ± 0.00 mg/kg), zinc (20.30 ± 5.77 - 29.86 ± 3.33 mg/kg), copper (1.37 ± 0.03 – 21.33 ± 0.03 mg/kg) and manganese (3.43 ± 0.09 - 7.10 ± 0.06 mg/kg), while nickel, lead and cadmium were not detected in any of the samples. However, the mineral contents of the formulated snacks were higher in sodium, iron and copper, but lower in potassium than in the control sample. In this present study, the values of iron in the snacks were higher than diabetic snacks made from afzelia africana and detarium microcarpium seed flour reported by Onyechi et al. (2013). Iron is an essential trace element for haemoglobin formation, cognitive development and in the oxidation of carbohydrates, proteins and fats (Adeye and Otokiti, 1999). The ratios of sodium to potassium (Na/K) of the snacks ranged from 1.87 in SWC1 to 7.5 in SC sample, and the values were higher than in control samples (0.60). The recommended value for Na/K in human is less than one (<0.01), since Na/K molar ratios in these snacks were higher than one (Ogbuagu et al., 2011), it implies that the formulated snacks contain large amount of sodium relative to potassium and this might not be suitable for people with cardiovascular diseases (Ogbuagu et al., 2011). Evidence has shown that high intakes of potassium against sodium prevent

### Table 1. Proximate composition (%) of the formulated snacks.

<table>
<thead>
<tr>
<th>Samples</th>
<th>CS</th>
<th>SWC1</th>
<th>SWC2</th>
<th>SWC3</th>
<th>SC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>6.89±0.06</td>
<td>9.37±0.08</td>
<td>10.43±0.14</td>
<td>10.41±0.02</td>
<td>9.04±0.09</td>
</tr>
<tr>
<td>Crude protein</td>
<td>12.43±1.28</td>
<td>51.09±1.08</td>
<td>56.01±5.03</td>
<td>67.00±3.91</td>
<td>57.33±2.78</td>
</tr>
<tr>
<td>Crude fat</td>
<td>2.81±0.04</td>
<td>3.85±0.24</td>
<td>3.45±0.16</td>
<td>3.18±0.11</td>
<td>3.32±0.16</td>
</tr>
<tr>
<td>Total ash</td>
<td>2.41±0.12</td>
<td>4.49±0.31</td>
<td>5.61±0.20</td>
<td>5.97±0.02</td>
<td>5.80±0.00</td>
</tr>
<tr>
<td>Crude fiber</td>
<td>2.77±0.01</td>
<td>5.30±0.04</td>
<td>4.81±0.00</td>
<td>4.08±0.00</td>
<td>6.09±0.00</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>72.68±1.19</td>
<td>25.73±1.42</td>
<td>19.69±4.75</td>
<td>9.35±3.86</td>
<td>18.42±2.73</td>
</tr>
<tr>
<td>Energy</td>
<td>365.73±11.01</td>
<td>342.01±9.21</td>
<td>333.69±13.1</td>
<td>334.02±7.33</td>
<td>332.88±6.71</td>
</tr>
</tbody>
</table>

Values with different superscript on the row are significantly (ps<0.05) different
CS – control sample (chewy snack)
SWC1 – soy concentrate- 65%, cassava fibre 22%, and wheat 13%
SWC2- soy concentrate- 75%, cassava fibre 18%, and wheat 7%
SWC3- soy concentrate- 85%, cassava fibre 13%, and wheat 2%
SC- soy concentrate- 75% and cassava fibre 25%.
cardiovascular diseases (Ogbuagu et al., 2011). Potassium is an essential nutrient and has an important role in the synthesis of amino acid and protein in man (Malik and Scivastava, 1982).

### Amino acid profile of formulated snacks and control snack

The amino acid compositions of the formulated snacks are presented in Table 3. The Amino acid contents and their values ranged were as follows: isoleucine 3.22 - 3.80g/100g, leucine 7.75 - 10.6g/100g, lysine 3.77 - 4.65g/100g, methionine 0.90 - 1.53g/100g, phenylalanine 3.85-5.88g/100g, threonine 3.01-3.79g/100g, valine 3.33-4.46g/100g, histidine 3.38 - 3.86g/100g, tryptophan 0.72 - 0.95g/100g, alanine 3.48 - 6.15g/100g, cysteine 0.62 - 1.42g/100g, tyrosine 2.88 - 3.29g/100g arginine 4.25 - 7.92g/100g, aspartic acid 9.13 - 13.34g/100g, glutamic acid 19.83 - 23.93g/100g, glycine 3.63-3.98g/100g, serine 5.80-6.23g/100g and proline 7.11 - 9.82g/100g. Comparatively, the percentage of total essential amino acids (TEAAs) of the snacks ranged from 31.19% in SWC1 to 32.29% in SWC3, and the values were lower than in the control snack (CS) (36.83%).

The predicted nutritional quality of the formulated snacks is presented in Table 3. The percentage of total essential amino acids including histidine and arginine ranged from 39.31% in SC to 43.59% in SWC3, and the values were lower when compared with the control sample CS (46.69%). The predicted protein efficiency ratio (PER) of the samples ranged from 2.32 in SC to 2.71 in SWC3, and the values were lower when compared with the control sample (2.77). Essential amino acid index (EAAI) of the snacks ranged from 55.44% in SC to 160.94% in SWC3, while that of control sample was 111.26%. The predicted biological value (BV) of the formulated snacks ranged from 48.73% in SC to 163.72% in SWC3, while that of control sample was 109.57%. The most abundant amino acid was glutamic acid (212-216%), while the limiting amino acid was methionine with ranged values between 30% in SWC1 and 43% in SWC3.

The protein content of the snacks was high due to the soybean protein isolate supplementation. It is evident that soybean contain appreciable amount of protein, and that combination of soybean protein (a legume) with wheat flour (a cereal) a balanced essential amino acid profile is achieved by complementing each other (Klein et al., 1995; Lang, 1999). The total essential amino acid (TEAA) with histidine and arginine of formulated snacks were within the values recommended per day by the FAO/WHO for infants (39%), children (26%) and adults (11%) (FAO/WHO, 1991). Comparatively, it was observed that the essential amino acid index (EAAI), predicted-protein efficiency ratio (P-PER), predicted biological values (P-BV) and nutritional index (NI) of the formulated snacks were comparable to that of the control samples. Nutritionally, a protein-based food material is said to be of good nutritional quality when its protein efficiency ratio is 2.7, biological values is >70%, essential amino acid index (EAAI) is >0.70 (Oser, 1959). The nutritional outcome of formulated snacks of the present study in terms of essential amino acid index, protein efficiency ratio and biological value showed that the snacks contain appreciable amount of protein to meet daily requirements of consumers.

### Antinutritional contents of the formulated snacks

Anti-nutritional contents of the formulated snacks are presented in Table 4. Tannin contents ranged from 0.48 in SWC3 to 0.82mg/100g in SWC1, and were significantly...
Table 3. Amino Acid (g/100g protein) profile and predicted nutritional quality of the snacks and control sample.

<table>
<thead>
<tr>
<th>Samples</th>
<th>CS</th>
<th>SWC1</th>
<th>SWC2</th>
<th>SWC3</th>
<th>SC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isoleucine</td>
<td>3.22±0.01</td>
<td>3.60±0.00</td>
<td>3.40±0.01</td>
<td>3.80±0.00</td>
<td>3.80±0.00</td>
</tr>
<tr>
<td>Leucine</td>
<td>10.6±0.00</td>
<td>7.89±0.00</td>
<td>7.75±0.00</td>
<td>7.88±0.01</td>
<td>8.02±0.01</td>
</tr>
<tr>
<td>Lysine</td>
<td>3.77±0.00</td>
<td>3.99±0.01</td>
<td>4.46±0.00</td>
<td>4.60±0.00</td>
<td>4.65±0.00</td>
</tr>
<tr>
<td>Methionine</td>
<td>1.53±0.01</td>
<td>0.90±0.01</td>
<td>1.16±0.00</td>
<td>1.30±0.00</td>
<td>0.92±0.00</td>
</tr>
<tr>
<td>Threonine</td>
<td>3.79±0.00</td>
<td>3.03±0.01</td>
<td>3.01±0.01</td>
<td>3.02±0.01</td>
<td>3.04±0.00</td>
</tr>
<tr>
<td>Valine</td>
<td>4.46±0.01</td>
<td>3.47±0.02</td>
<td>3.33±0.01</td>
<td>3.64±0.00</td>
<td>3.66±0.01</td>
</tr>
<tr>
<td>Histidine</td>
<td>3.86±0.03</td>
<td>3.53±0.01</td>
<td>3.61±0.01</td>
<td>3.38±0.00</td>
<td>3.38±0.01</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>0.86±0.00</td>
<td>0.95±0.00</td>
<td>0.86±0.00</td>
<td>0.94±0.00</td>
<td>0.72±0.00</td>
</tr>
<tr>
<td>Cysteine</td>
<td>1.42±0.00</td>
<td>0.88±0.01</td>
<td>0.84±0.00</td>
<td>0.81±0.00</td>
<td>0.62±0.00</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>3.29±0.01</td>
<td>2.88±0.01</td>
<td>2.92±0.01</td>
<td>2.92±0.00</td>
<td>2.87±0.01</td>
</tr>
<tr>
<td>Alanine</td>
<td>6.15±0.00</td>
<td>3.63±0.00</td>
<td>3.56±0.01</td>
<td>3.48±0.00</td>
<td>3.52±0.01</td>
</tr>
<tr>
<td>Arginine</td>
<td>6.00±0.00</td>
<td>7.36±0.01</td>
<td>7.80±0.01</td>
<td>7.92±0.01</td>
<td>4.25±0.00</td>
</tr>
<tr>
<td>Aspartic Acid</td>
<td>9.13±0.01</td>
<td>13.03±0.01</td>
<td>13.03±0.00</td>
<td>12.92±0.01</td>
<td>13.34±0.00</td>
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<tr>
<td>Glutamic Acid</td>
<td>19.83±0.00</td>
<td>23.93±0.04</td>
<td>23.54±0.01</td>
<td>23.07±0.00</td>
<td>23.19±0.01</td>
</tr>
<tr>
<td>Glycine</td>
<td>3.98±0.00</td>
<td>3.73±0.00</td>
<td>3.66±0.00</td>
<td>3.63±0.01</td>
<td>3.64±0.00</td>
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<tr>
<td>Phenylalanine</td>
<td>4.96±0.01</td>
<td>5.74±0.00</td>
<td>5.75±0.00</td>
<td>5.88±0.01</td>
<td>3.85±0.00</td>
</tr>
<tr>
<td>Proline</td>
<td>9.82±0.01</td>
<td>7.66±0.01</td>
<td>7.54±0.00</td>
<td>7.20±0.01</td>
<td>7.11±0.00</td>
</tr>
<tr>
<td>Serine</td>
<td>5.80±0.00</td>
<td>6.23±0.00</td>
<td>6.21±0.00</td>
<td>6.03±0.01</td>
<td>6.14±0.00</td>
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</tbody>
</table>

Predicted Nutritional Quality

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>TAA%</td>
<td>46.69</td>
</tr>
<tr>
<td>TEAA/TAA%</td>
<td>36.83</td>
</tr>
<tr>
<td>TNEAA/TAA%</td>
<td>63.17</td>
</tr>
<tr>
<td>TSAA(Meth+Cys)</td>
<td>2.95</td>
</tr>
<tr>
<td>ArEAA</td>
<td></td>
</tr>
<tr>
<td>(Phe+Tyr)</td>
<td>8.25</td>
</tr>
<tr>
<td>TEAA/TNEAA</td>
<td>0.58</td>
</tr>
<tr>
<td>PER (g/100g)</td>
<td>2.77</td>
</tr>
<tr>
<td>EAAI</td>
<td>1.11</td>
</tr>
<tr>
<td>BV (%)</td>
<td>109.57</td>
</tr>
<tr>
<td>Nutritional index (%)</td>
<td></td>
</tr>
<tr>
<td>1st Limiting AA (Methionine) (%)</td>
<td>13.83</td>
</tr>
<tr>
<td>2nd Limiting AA (Tryptophan) (%)</td>
<td>72</td>
</tr>
<tr>
<td>Highest AA (Glutamic acid) (%)</td>
<td>182</td>
</tr>
</tbody>
</table>

Each value is a mean ± standard deviation of three replicates samples; Values with different superscript on the row are significantly (p ≤ 0.05) different

TEAA- Total essential amino acids; TNEAA-Total non-essential amino acids; PER- Protein efficiency ratio

EAAI- Essential amino acid index; BV- Biological values; CS –control sample (chewy snack)

SWC1 – soy concentrate- 65%, cassava fibre 22%, and wheat 13%

SWC2- soy concentrate- 75%, cassava fibre 18%, and wheat 7%

SWC3- soy concentrate- 85%, cassava fibre 13%, and wheat 2%

SC- soy concentrate- 75% and cassava fibre 25%.

different when compared with the control sample, except in SWC1. Phytate contents of the samples ranged between 406.29 and 559.83mg/100g in SC and 559.83 mg/100g samples respectively. Oxalate contents of the snacks ranged between 35.75 and 72.41mg/100g, and were lower than that of control sample (CS). Hydrogen cyanide contents of the samples ranged between 0.057 mg/100g in SC to 0.079 mg/100g in SWC3 sample. The trypsin inhibitor activities of the samples showed that sample SC had the highest value (49.63%), while SWC3
The high level of uric acid in the blood causes negative side effects to the consumers’ health.

Microbiological evaluation of snacks

The microbial loads of the snacks are shown in Table 5. Total mesophilic bacteria count was only detected in CS sample ($1.3 \times 10^7$ cfu) and it was not detected in other formulated samples. The total yeast/mould count was detected in CS ($3.0 \times 10^6$ cfu) and SWC1 ($2.0 \times 10^5$ cfu) samples and not detected in the remaining formulated samples. E. coli, coliform, S. aureus, Lactic acid bacteria, Salmonella, were not detected in any of the snack samples. The microbiological quality of snacks was within the limit of the minimum standard for total number of mesophilic bacteria and yeast and mould, while E. coli, coliform, S. aureus, Lactic acid bacteria salmonella and shigella were not present in the snacks. It is well known that microbial contamination is one of the major causes of ill health in infants and young children (Motarjemi et al., 2000). Evidence has shown that diarrhoea is the second leading cause of death in children (UNICEF/WHO, 2009),

<table>
<thead>
<tr>
<th>Samples</th>
<th>Total Mesophilic bacteria</th>
<th>Total yeast and mould</th>
<th>Total E. coli</th>
<th>Total Coliform</th>
<th>Total S. aureus</th>
<th>Total Lactic Acid bacteria</th>
<th>Total Salmonella and Shigella</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS</td>
<td>$1.3 \times 10^7$</td>
<td>$3.0 \times 10^5$</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
</tr>
<tr>
<td>SWC1</td>
<td>NIL</td>
<td>$2.0 \times 10^5$</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
</tr>
<tr>
<td>SWC2</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
</tr>
<tr>
<td>SWC3</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
</tr>
<tr>
<td>SC</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
<td>NIL</td>
</tr>
</tbody>
</table>

CS – control sample (chewy snack)
SWC1 – soy concentrate- 65%, cassava fibre 22%, and wheat 13%
SWC2- soy concentrate- 75%, cassava fibre 18%, and wheat 7%
SWC3- soy concentrate- 85%, cassava fibre 13%, and wheat 2%
SC- soy concentrate- 75% and cassava fibre 25%

had the lowest value (38.97%). Uric acid concentration in the samples ranged between 0.25 and 8.93 mg/100g. Tannin, phytate, oxalate and trypsin concentrations in the snacks were relatively low, and the concentrations would not affect the digestion and absorption of protein and minerals by chelating with the nutrients to form complex compound, and thereby reduce the bioavailability of protein and mineral in man (Groff et al., 1995). The hydrogen cyanide (HCN) concentrations of the snacks were low, and this could be attributed to the processing methods that were adopted during the preparation of cassava fiber flour, i.e., soaking, pressing and drying. High level of HCN has been implicated for cerebral damage and lethargy in man and animals (Akyildiz et al., 2010; Ekop et al., 2010). The formulated snacks contain traces of uric acid, which is within the tolerable level. Uric acid is a byproduct of the breakdown of purines, compounds that occur naturally in a variety of plant- and animal-based foods. Soybean is one of the purine rich foods that cause high uric acid level in blood on metabolism. High level of uric acid in the blood causes gout. In view of the low concentration of uric acid in these snacks, intake of the products would not have any negative side effects to the consumers’ health.

Table 4. Anti nutritional factors (mg/100g) of the formulated snacks.

<table>
<thead>
<tr>
<th>SAMPLES</th>
<th>CS</th>
<th>SWC1</th>
<th>SWC2</th>
<th>SWC3</th>
<th>SC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tannin</td>
<td>$0.81 \pm 0.30$</td>
<td>$0.82 \pm 0.01$</td>
<td>$0.54 \pm 0.01$</td>
<td>$0.48 \pm 0.01$</td>
<td>$0.69 \pm 0.01$</td>
</tr>
<tr>
<td>Phytate</td>
<td>$550.86 \pm 14.7$</td>
<td>$557.83 \pm 15.9$</td>
<td>$559.83 \pm 11.0$</td>
<td>$490.29 \pm 4.11$</td>
<td>$406.29 \pm 5.71$</td>
</tr>
<tr>
<td>Oxalate</td>
<td>$72.41 \pm 0.19$</td>
<td>$72.22 \pm 0.19$</td>
<td>$35.75 \pm 0.36$</td>
<td>$27.55 \pm 0.54$</td>
<td>$51.31 \pm 2.71$</td>
</tr>
<tr>
<td>Cyanide</td>
<td>$0.163 \pm 0.04$</td>
<td>$0.061 \pm 0.15$</td>
<td>$0.079 \pm 0.22$</td>
<td>$0.079 \pm 0.22$</td>
<td>$0.057 \pm 0.11$</td>
</tr>
<tr>
<td>Trypsin Inhibitor</td>
<td>$28.25 \pm 0.13$</td>
<td>$45.24 \pm 0.06$</td>
<td>$42.11 \pm 0.00$</td>
<td>$38.97 \pm 0.48$</td>
<td>$49.63 \pm 0.00$</td>
</tr>
<tr>
<td>Uric-Acid</td>
<td>$5.72 \pm 0.06$</td>
<td>$3.50 \pm 0.16$</td>
<td>$0.25 \pm 0.05$</td>
<td>$0.82 \pm 0.04$</td>
<td>$8.93 \pm 0.62$</td>
</tr>
</tbody>
</table>

Each value is a mean ± standard deviation of three replicates samples; Values with different superscript on the row are significantly (p≤ 0.05) different

CS – control sample (chewy snack)
SWC1 – soy concentrate- 65%, cassava fibre 22%, and wheat 13%
SWC2- soy concentrate- 75%, cassava fibre 18%, and wheat 7%
SWC3- soy concentrate- 85%, cassava fibre 13%, and wheat 2%
SC- soy concentrate- 75% and cassava fibre 25%

Table 5. Microbiological status of the formulated snacks and control sample.

had the lowest value (38.97%). Uric acid concentration in the samples ranged between 0.25 and 8.93 mg/100g. Tannin, phytate, oxalate and trypsin concentrations in the snacks were relatively low, and the concentrations would not affect the digestion and absorption of protein and minerals by chelating with the nutrients to form complex compound, and thereby reduce the bioavailability of protein and mineral in man (Groff et al., 1995). The hydrogen cyanide (HCN) concentrations of the snacks were low, and this could be attributed to the processing methods that were adopted during the preparation of cassava fiber flour, i.e., soaking, pressing and drying. High level of HCN has been implicated for cerebral damage and lethargy in man and animals (Akyildiz et al., 2010; Ekop et al., 2010). The formulated snacks contain traces of uric acid, which is within the tolerable level. Uric acid is a byproduct of the breakdown of purines, compounds that occur naturally in a variety of plant- and animal-based foods. Soybean is one of the purine rich foods that cause high uric acid level in blood on metabolism. High level of uric acid in the blood causes gout. In view of the low concentration of uric acid in these snacks, intake of the products would not have any negative side effects to the consumers’ health.
and is a leading cause of growth faltering and malnutrition (Motarjemi et al., 1993). Hence, the formulated snacks in this present study would not pose any threat and are suitable for human consumption.

**Functional and physical properties of the formulated snacks**

The results of the functional properties of the snacks are shown in Table 6. Water absorption capacity (WAC) of the snacks ranged between 1.77% and 2.20%, while oil absorption capacity (OAC) ranged between 0.87 and 1.78%. Loose bulk density (LBD) of the snacks ranged between 0.60 and 0.80g/ml. Packed bulk density (PBD) was between 0.90 and 1.20g/ml and least gelation concentration (LGC) was between 0.60 and 0.80g/ml. Water absorption capacity (WAC) of the snacks ranged between 4.60% and 5.27%. Swelling capacity of the snacks ranged between 0.43 and 0.70%. Thickness of the snacks ranged between 1.77% and 2.20%, while oil absorption capacity (OAC) ranged between 0.63 ± 0.03 and 0.70 ± 0.00.

<table>
<thead>
<tr>
<th>Samples</th>
<th>CS</th>
<th>SWC1</th>
<th>SWC2</th>
<th>SWC3</th>
<th>SC</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAC %</td>
<td>5.27±0.07</td>
<td>2.20±0.20</td>
<td>1.77±0.07</td>
<td>4.07±0.03</td>
<td>2.07±0.03</td>
</tr>
<tr>
<td>OAC %</td>
<td>3.85±0.12</td>
<td>1.58±0.06</td>
<td>1.03±0.09</td>
<td>1.78±0.04</td>
<td>0.87±0.07</td>
</tr>
<tr>
<td>LBD g/ml</td>
<td>0.80±0.05</td>
<td>0.60±0.00</td>
<td>0.68±0.00</td>
<td>0.71±0.01</td>
<td>0.78±0.01</td>
</tr>
<tr>
<td>PBD g/ml</td>
<td>2.00±0.12</td>
<td>1.20±0.29</td>
<td>0.96±0.09</td>
<td>0.93±0.09</td>
<td>0.92±0.08</td>
</tr>
<tr>
<td>SC %</td>
<td>4.60±0.00</td>
<td>0.82±0.02</td>
<td>0.65±0.03</td>
<td>0.82±0.02</td>
<td>0.80±0.00</td>
</tr>
<tr>
<td>LGC %</td>
<td>0.43±0.03</td>
<td>0.63±0.03</td>
<td>0.70±0.00</td>
<td>0.77±0.03</td>
<td>0.60±0.00</td>
</tr>
<tr>
<td>Diameter</td>
<td>2.10±0.05</td>
<td>0.70±0.05</td>
<td>0.81±0.02</td>
<td>0.83±0.00</td>
<td>0.71±0.01</td>
</tr>
<tr>
<td>Length</td>
<td>2.43±0.06</td>
<td>4.08±0.16</td>
<td>4.37±0.23</td>
<td>4.88±0.14</td>
<td>3.54±0.02</td>
</tr>
<tr>
<td>Thickness</td>
<td>4.17±0.01</td>
<td>4.16±0.01</td>
<td>4.20±0.00</td>
<td>4.19±0.00</td>
<td>4.17±0.00</td>
</tr>
</tbody>
</table>

Each value is a mean ± standard deviation of three replicates samples; Values with different superscript on the row are significantly (p<0.05) different

WAC – Water absorption capacity, PBD – Packed bulk density
OAC - Oil absorption capacity, SC – Swelling capacity
LBD – Loose bulk density, LGC – Least gelation concentration
CS – Control sample (chewy snack)
SWC1 – Soy concentrate- 65%, cassava fibre 22%, and wheat 13%
SWC2- Soy concentrate- 75%, cassava fibre 18%, and wheat 7%
SWC3– Soy concentrate- 85%, cassava fibre 13%, and wheat 2%
SC- Soy concentrate- 75% and cassava fibre 25%

Table 6. Functional and physical properties of the functional snacks.

This functionality is important in the food systems in terms of interactions of water or oil with proteins for enhancing the flavor, texture of the foods and baking properties. Bulk density is a measure of heaviness of flour (Oladele and Aina, 2007), and it is an important parameter that determines the packaging requirement of a product. Bulk density signifies the behavior of a product in dry mixes and it varies with the fineness of the particles. Increase in bulk density is desirable in that it offers greater packaging advantage as greater quantity may be packed within constant volume (Molina et al., 1983). However, low bulk density is desirable in preparation of infant and weaning foods. Stojceska et al. (2009) reported that bulk density is highly correlated to the moisture content of the product during extrusion. Least gelation concentration (LGC), which is defined as the lowest protein concentration at which gel remained in the inverted tube was, used as index of gelation capacity, and the lower the value the better the gelating ability of the protein ingredient (Akintayo et al., 1999).

Physical characteristics of the snacks including diameter, length and thickness are presented in Table 6. The diameter of the snacks ranged between 0.70 - 83mm, length was between 2.43 and 4.48mm, and thickness was between 4.16 and 4.20mm. Statistically, there was significant difference in the diameter, length, and thickness of the control sample (CS) and formulated snacks. However, there was no significant difference observed between the diameters and thickness of the formulated snacks. Physical characteristics of snacks, such as thickness, diameter and length, were affected significantly (P < 0.05) with the increase in the level of both the soy concentrate and the wheat flour in the blends. It is evident from this study that the diameter of the control biscuit (CS) was higher than those of formulated snacks. This could be attributed to the size of die used during cold extrusion. These finding agreed with the report of Clauthon and Pearce (1989). It was observed that there was no significant difference in the thickness of the blends with higher soy concentrate quantity; however, there was significant difference in the...
thickness of the blends with lower soy concentrate quantity and that of control sample. Reduced thickness of snacks from blends of different ratios of flour samples was attributed to the fact that composite flours apparently form aggregates with increased numbers of hydrophilic sites available for competing for the limited free water (Hooda and Jood, 2005; Rababah et al., 2006). Rapid partitioning of free water of these hydrophilic sites occurs during dough mixing and increases dough viscosity, thereby limiting snack spread and top grain formation during baking. These results agreed with those reported by Rababah et al., (2006) and Yadav et al., (2012).

**Sensory attribute of the Snacks**

Fresh snacks were evaluated for taste, hardness, aroma, firmness and overall acceptability as presented in Table 7. The results of sensory attributes of the formulated snacks showed that there was no significant difference (p < 0.05) between the formulated products in terms of taste, hardness, aroma, firmness, and overall acceptability, but there was significant difference (p < 0.05) between these products and control sample. This observation could be attributed to the fact that the panelist might have been familiar with the control sample; hence, this might have influenced their judgment in favour of the control sample relatively to the formulated snacks. However, in overall acceptability samples SWC1 and SC were both rated next to the control sample. The disparity observed between the sensory attributes of control sample over the formulated snacks agreed with the report of Akubor and Ukwuru (2005), who studied the effect of soy flour on the functional properties and biscuit making potentials of soybean and cassava flour blends.

**Conclusion**

The findings of this research established that, the snacks produced with soybean flour substitution up to 20% were nutritionally superior to that of the control chewy products. The high protein and fibre content in the cassava-soy concentrate and wheat formulated snacks would be of nutritional importance in most developing countries like Nigeria where many people can hardly afford quality protein-based foods. Hence, the present products would complement protein intakes of the consumers and also prevent nutritional related diseases like protein-energy malnutrition, diabetes, obesity and cardiovascular diseases.

**REFERENCES**


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**Table 7. Sensory quality of the formulated snacks.**

<table>
<thead>
<tr>
<th>Samples</th>
<th>Taste</th>
<th>Hardness</th>
<th>Aroma</th>
<th>Firmness</th>
<th>Overall Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS</td>
<td>7.8a ± 0.21</td>
<td>7.7a ± 0.20</td>
<td>7.5a ± 0.25</td>
<td>7.7a ± 0.19</td>
<td>7.9a ± 0.22</td>
</tr>
<tr>
<td>SWC1</td>
<td>5.2b ± 0.43</td>
<td>5.7b ± 0.43</td>
<td>5.4b ± 0.39</td>
<td>5.9b ± 0.35</td>
<td>5.7b ± 0.38</td>
</tr>
<tr>
<td>SWC2</td>
<td>5.6b ± 0.38</td>
<td>5.7b ± 0.41</td>
<td>5.6b ± 0.33</td>
<td>5.9b ± 0.31</td>
<td>5.5b ± 0.35</td>
</tr>
<tr>
<td>SWC3</td>
<td>5.0b ± 0.38</td>
<td>5.5b ± 0.43</td>
<td>5.3b ± 0.36</td>
<td>5.7b ± 0.35</td>
<td>5.1b ± 0.39</td>
</tr>
<tr>
<td>SC</td>
<td>5.6b ± 0.33</td>
<td>5.6b ± 0.43</td>
<td>5.3b ± 0.37</td>
<td>5.9b ± 0.33</td>
<td>5.7b ± 0.35</td>
</tr>
</tbody>
</table>

Each value is a mean ± standard deviation of three replicates samples Values with different superscript on the column are significantly (p ≤ 0.05) different.

CS – control sample (chewy snack)

SWC1 – soy concentrate- 65%, cassava fibre 22%, and wheat 13%

SWC2 - soy concentrate- 75%, cassava fibre 18%, and wheat 7%

SWC3- soy concentrate- 85%, cassava fibre 13%, and wheat 2%

SC- soy concentrate- 75% and cassava fibre 25%.


Makkar AOS, Goodchild AV (1996). Quantification of tannin. A Laboratory manual Information Center for Agricultural Research in the areas of Aleppo, Syria.


