Physiochemical, In-Vitro Digestibility and Organoleptic Evaluation of “Acha” Wheat Biscuit Supplemented with Soybean Flour

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ABSTRACT

Biscuits were produced from wheat-“acha” (7:3) composite flour (WAF) and soybean flour (SBF) blends. The various ratios of WAF to SBF used were 100:00, 95:05, 90:10, 85:15, 80:20 and 70:30. The biscuits were analyzed for physical (weight, spread ratio, break strength), chemical (protein, fats, ash, carbohydrate, water), in-vitro (protein and starch) digestibility and organoleptic (colour, taste, odour, texture) qualities. The weight and break strength of the WAF-SBF biscuits decreased from 11.61 to 8.81%, and 2.11 to 1.13%, respectively, while the spread ratio increases from 4.74 to 6.43 with increase in the soybean blend (0 – 30%). The protein, fat and energy (calorie) content of the biscuits increased from 5.0 to 14.19%, 14.80 to 24.01% and 422.34 to 476.42 kcal/g, while the moisture, ash and carbohydrate content decreased from 2.9 to 1.56, 9.79 to 9.35 and 67.51 to 50.89%, respectively, with increase in the soybean blend (0 to 30%). The decrease in the in-vitro starch and protein digestibility of the biscuit increased from 2.09 to 11.9% and 0.18 to 2.39%, respectively with increase in the percentage (0 – 30%) soybean flour. Generally the mean scores for all the assessed sensory parameters decreased with increase in the soybean blend, and were significant at above 15%, p= 0.05.

Key words- Physiochemical, In-vitro digestibility, organoleptic, nutritional, acha, wheat, soybean, biscuit.

INTRODUCTION

The consumption of cereal foods such as biscuits and bread has become very popular in Nigeria; especially among children. Most of these foods are, however, poor sources of protein that is often of poor nutritional quality (Akpapunam, 1994, Alobo 2001). Enrichment of cereal- based foods with other protein sources such as oil seeds and legumes has received considerable attention (Okaka and Isieh, 1980, Dhingra and Jood, 2005, Alobo, 2001, Elkahifa and El-tinay 2002, Ayo and Gafa, 2002, Ayo and Olawale, 2003, Grewal, 1992). This is because of oil seed and legumes proteins are high in lysine, an essential limiting amino acid in most cereal (FAO, 1970)

The use of any food raw material in processing depends on its availability. The main problem facing the bakery industry in Nigeria is the total dependence on importation of wheat to sustain it. Nigeria has unfavorable climatic condition for wheat cultivation, but suitable for other cereal (sorghum, maize, millet, “acha”); legumes (soybean, groundnut, bambara nut, cowpeas) and vegetable (Eneche, 1999). Therefore any effort made to substitute part of the wheat flour by other kinds of available flours e.g sorghum, millet; “acha” will contribute to lowering of cost.

“Acha” (Digitaria exilis) commonly referred
to as fonio, finni, hungry rice (Rachie, 1974, Jideani and Akingbala 1993), is probably one of the oldest Africa cereals (NRC, 1996) and classified as one of the lost crops of Africa. “Acha” crops are exceptionally tolerant to a wide variety of conditions, particularly drought and poor soil (NRC, 1996). The grains are widely produced in the area of growth (Bauchi, Plateau, Kaduna States of Nigeria) and used for human nutrition. They are processed and consumed in a variety of ways such as “tuwo”, “kunun”, “gote” and whole grains in soup and porridge (Jideani 1999). “Acha” is reported to have a high pentosan (3.3%), hence high water absorption capacity that could be utilized in baked goods (Lasekan 1994) and uniquely rich in methionine and cystine (NRC, 1996), and relatively evoke low sugar on consumption (Ayo et al., 2003) an advantage for diabetics. Wheat flour blended with “acha” flour up to 30% has shown no significant difference in terms of sensory qualities (Ayo and Nkama, 2003).

Grain legumes, like soybean contribute 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 stables such as legumes/ pulses helps in improving the nutritional quality of cereal product (Sharma et al., 1999).

This work is a follow up work on effect of “acha” (Digitaria exilis) grain flour on the physical and sensory quality of biscuit (Ayo and Nkama, 2003). In this present study, efforts have been made to supplement wheat-“acha” (70-30) flour with soybean flour (0-30%) to develop nutritionally rich functional foods such as biscuit.

MATERIALS AND METHODS

Source and Preparation of Raw Materials

“Acha” (Digitaria exilis), the creamy coloured type, locally grown, was purchased at Jos central market, Jos, Plateau State, Nigeria. The “acha” was manually cleaned by handpicking of the chaff and the dust and stones were removed by washing in tap water (sedimentation) using local calabash. The washed and de-stoned grains were dried at 45°C in a hot air cabinet Dryer (APV- machine Dryer) to a moisture content of 11.91%, milled using attrition milling machine (Lister Inc England). The flour was sieved to pass through 0.4mm mesh size (No 2 screens) and vacuum packaged (Phlico Vacuum sealer, Hongkong) in polyethylene. The soybean was cleaned, toasted lightly in a hot air rotary oven (BCH Air oven England) improve de-hulling and destruction of anti nutritional factors such as protease inhibitors and polyphenols, mostly present in the seed coat (Eneche, 1999). The de-hulled beans were milled and sieved and packaged as done for “acha” flour. The flours were kept under refrigerated temperature (4-6°C) to prevent spoilage particularly rancidity until usage.

Preparation of Wheat – Acha/ Soybean Flour Biscuits

The wheat flour is blended with “acha” (7:3) in line with the maximum acceptable cereals blend in the early work (Ayo and Nkama, 2003). The preparation of the biscuits involved the replacement of part of the wheat-”acha” flour (WAF) with 5, 10, 15, 20, and 30% soybean flour (SBF). The 100% WAF biscuit served as the control. All the biscuit contained 35 parts sugar, 50 part of margarine (fat), and 1.0 part baking powder, 0.1 parts of salt and 7.5 parts of liquid (peak?) milk. The Oyewole et al (1996) and Ayo and Nkama (2003) method of biscuit production was adopted. The sugar and fat were mixed using
a Kenwood mixer at medium speed until fluffy. The 7.5 part of the liquid milk were added and mixed for 30 min. The WAF/ SBF composite flour baking powder and salt were slowly added into the mixture and mixed until a uniform smooth paste was obtained. The paste was rolled on a flat rolling board sprinkled with the same flour to a uniform thickness of 0.4 cm using a wooden rolling pin. Circular biscuits of 4.0 cm diameter were cut (using a biscuit-cutter), placed on a greased baking tray and baked at 160°C for 15 min (BCH- Rotary oven, Great Britain). The biscuit was allowed to cool down and hermetically sealed.

**Physical Analysis**

The weight and the diameter of the baked biscuit were determined by weighing on a weighing balance (Santual Electronic Weighing Balance) and measuring with a calibrated ruler, respectively.

The spread ratio was determined using Gomez et al (1997) method. Three rows of five well-formed biscuits were made and the height measured. Also the same were arranged horizontally edge to edge and the sum diameter measured. The spread ratio is calculated as diameter / height.

The break strength of the biscuit was determined using Okaka and Isieh (1990) method. Biscuit of known thickness (0.4 cm) was placed between two parallel wooden bars (3 cm apart). Weights were added on the biscuit until the biscuit snapped. The least weight that caused the breaking of the biscuit was regarded as the break strength of the biscuit.

**Chemical Analysis**

The moisture content (hot air oven method), fat (soxhlet extraction method) were determined according to Pearson (1976) while the ash, and protein were determined using AOAC (1990) methods. The carbohydrate content was determined by simple difference and calorie value was estimated using Atwater factors by multiplying the proportion of protein, fat, and carbohydrate by their respective physiological fuel values of 4.9 and 4 kcal/g, respectively, and taking the sum of the products (Eneche, 1999).

**In-Vitro Protein Digestibility (IVPD)-** Protein (pepsin) digestibility in wheat—"acha" and wheat—"acha" soybean flours / biscuits were determined using the procedure described by Mertz et al. (1994) and Aboubaear et al. (2001). Flour samples (200 mg) were weighed into Erlenmeyer flask and mixed with 35 ml of porcine pepsin (Sigma –P.700, activity 890 U/ mg of protein, Sigma chemical co. SL Louis, Mo) solution (1.5g of pepsin in 0.1M KH₂PO₄, PH 2-0). Samples were digested for 2 h at 37°C in a shaking water bath. Digestion was stopped by addition of 2 ml of 2M NaOH. Samples were centrifuged (4, 900 xg, 40°C for 20 min, and the supernatant discarded. The residues were washed and centrifuged twice with 20ml of buffer (0.1 M KH₂PO₄, PH 7.0). Undigested nitrogen was determined using Kjeldahl method. Digestibility was calculated as

\[
\text{% digestibility} = \left( \frac{N_{\text{in sample}} - \text{Undigested N}}{N_{\text{in sample}}} \right) \times 100
\]

**In Vitro Carbohydrate Digestibility (IVCD)** - The Shekib et al (1988) method was used. The principle of the method is based on iodine – starch complex formation. The assay was carried out at room temperature (32°C) in a test tube containing 5 ml of he soluble starch containing solution 4 ml of phosphate buffer (PH 6.6), 1.0 ml of sodium chloride and 1.0 ml of á-amylase enzyme (Sigma- EC 22.1.1 VI B-Sigma chemical company Germany) was added and mixed thoroughly to make reaction mixture. Aliquots (0.2 ml) of the reaction was taken at zero and at 1.0 hour (complete hydrolysis as pre-determined) after addition of the enzyme and dispensed into 10.0 ml lugol’s iodine solution (1:100 dilution) and the
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absorbance measured colorimetrically at 620 nm with Corning Colorimeter 253. In-vitro carbohydrate is calculated as:-

\[
\text{Absorbance at zero time} - \text{absorb at 1.0 hour} \times 100
\]

Absorbance at zero time

**Organoleptic Evaluation of the Biscuit**

The sensory evaluation of the samples was carried out for consumer acceptance and preference using 20 untrained judges (students and staff of the Department of Food Science and Technology, Federal Polytechnic, Bauchi Nigeria), randomly selected using a nine point Hedonic scale (1 and 9 representing “extremely dislike” and “extremely like”, respectively). The mean scores were analyzed using analysis of variance (ANOVA) method and difference separated using Turkey test. Qualities assessed include: colour (crust and crumb), odour, taste, texture (crumb and crust) and general acceptance. Coded samples of the same size and temperature (30°C) were served in a coloured (white) plate of the same size to judges in each panel cupboard under the fluorescent light; only one sensory attribute was tested at one sitting. Unless otherwise maintained all the measurement were made in triplicate and the values represented the average of the three measurements.

**RESULTS AND DISCUSSION**

The weight of the biscuits were reduced (11.61 to 8.81g), while the diameter increased (20.52 to 23.63 cm) with increasing level of replacement with soybean flour (SBF) (0-30%) as showed in Table 1. SBF had a high and negative effect on the weight \( r = -0.96 \) of the biscuit. The decrease in weight could be due to the increase in the fat content of the blended soybean flour, as fat is lighter in weight. These results were similar to those 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).

The spread ratio increased (4.5 to 6.7) with increasing level of replacement with soybean flour (SBF) (0-30%). SBF had a high and positive effect on the spread ratio \( r = 0.98 \). The increase in the fats content (Table 2) could also affect the spread ratio.

The weight required breaking the biscuit which is the biscuit break strength, are shown in Table 1. The wheat–“acha” flour biscuit exhibited the highest break strength (2.2kg). The break strength decreased (2.2 to 0.7kg) with increase in percentage of soybean flour (0 to 30%). The decrease could be due to the increase in the percentage of fats (15.30 to 24.01%) with increase in percentage of soybean flour added, diluting the protein and carbohydrate level which are the principal compounds responsible for hardness in biscuits (Okaka and Isieh 1990).

The proximate analysis shown in Table 2 indicated that “acha” contained about 9.40 % protein compared to a 9.90% reported by Lasekan (1994). Fat content (0.101%) and ash content (0.266%), which were relatively lower than the results of NRC (1996) and Rachie (1974), could have been due to the de-hulling and de-germination of the grains used for the experiment.

The protein and the fat content increased from 5.0 to 14.19 and 14.70 to 24.01, respectively with increase in the percentage (0-30%) of soybean flour as shown in Table 3. The correlation relationship of the SBF with the protein and fat content is generally high and positive \( r = 0.90, 0.94 \) for protein and fat, respectively. The “acha”-wheat flour (AF) biscuit (control) (0% soybean flour) had the lowest protein content of 5.0%, which agree with the 5.1% noted by Pearson (1976). Similarly, the increase in the protein (7.6- 14.19%) and fats
(14 to 24.10%) content could be due to the increase in the proportion of soybean in the flour blended. This agreed with works that soybean flour has high protein (38 – 40%), fat (18 – 20%) and lysine (5 – 6%) content which have great potential in overcoming protein-calorie malnutrition (Rastogi and Singh, 1989).

The chemical analysis of the biscuits indicated that all the biscuits contained favourable proportion of protein, and fats. Thus, the protein and fat content of the soybean contributed to the protein and fat content of the biscuits. The nutritional value of the soybean is not the only factor enhancing its consumption, as it also plays an important role in the health (Steinke, 1992). All nine essential amino acids required by humans can be found in the amino acid consumption of soybean. Moreover, the essential amino acid content in soybean exceeds the amino acid requirements of children and adults, which confirms the protein quality of this vegetable (Steinke, 1992). Several workers have also reported an increase in protein content of food supplemented with soybean flour (Rathna and Neelakantan, 1995, Sharma and Chanhan 2000, Dhingra and Jood, 2000).

The carbohydrate content decreased (67.51 - 50.89%) with increase in the percentage (0 - 30%) of soybean flour added (Table 3). The effect was significant at above 10% added soybean flour, p= 0.05. The decrease could be due to the low content of carbohydrate in the added flour which agreed with the finding of Iwe (2004) that soybean are poor sources of carbohydrate.

The calorie content increased (424.34 – 476.41 cal) with increase in the percentage of soybean flour. The increase in the calorie content could be due to the high fat content of the added flour.

Research has shown that nutrient composition of foods is not enough to determine nutrient bio-availability (Davies and Austic 1982), hence the need for in-vitro (starch and protein) digestibility

The in-vitro protein digestibility (IVPD) for raw flour, baked and soybean – enriched “acha”, millet and wheat composite biscuits are summarized in Table 4. The IVPD for the unbaked (raw) “acha”, millet and wheat dough were 90.8, 92.6 and 93.2% while that for the baked samples are 86.5, 83.2 and 85.2%, respectively. The IVPD for the soybean (15%) enriched composite “acha”, millet and wheat biscuit were 83.1, 79.3 and 82.3%, respectively. Generally, the IVPD of the biscuit decreased (89.2 - 77.3%) with increase (0 - 30%) in the soybean flour as shown in Table 3.

The IVPD varied for the three (raw) samples (90.7-93.2%). Generally, the IVPD for the samples were significantly, (p< 0.05), affected by the baking process as shown by the values for the baked biscuits. The IVPD decreased from 90.7 to 86.5, 92.3 to 83.2 and 93.1 to 85.2 for acha, millet and wheat samples, respectively.

The IVSD of acha-wheat biscuits decreased (73.9 to 71.5%) with increase in the soybean flour (0-30%) as shown in Table 5. The correlation (r) of SBF with the IVSD is high and negative (-0.99). The decrease could be due to the replacement of “acha”–wheat flour with soybean flour, which has a lower digestible starch. The presence of trypsin and other enzyme inhibitors present in soybean (Sumathai and Pattabiraman, 1976) could have reduced the IVSD of the biscuit; as they bind to the substrate (starch) and make it unavailable to amylase during the protein digestion. Trypsin inhibitors present in soybean could be responsible for inhibiting the activity of proteolytic enzymes (Feng et al, 1991) as light toasting given the SBF may not have been able to destroy the inhibitors completely. Trypsin and related enzymes have been proved to be destroyed completely when subjected to heat under acidic conditions (Sumathai and
Pattabiraman, 1976) and wet heating (Singh and Singh, 1992; Geervani and Theophilus, 1981).

In-vitro protein digestibility is very important in accessing the quality of protein in a given product. It also helps to assess the effect of any processing effort on the same. The biological utilization of a protein is primarily dependent on its digestibility.

The IVPD values of the soybean biscuit decreased (98.2-77.3%) significantly with increase in soybean flour. (0 – 30 %) (Table 5). The decrease could be due to the high content of trypsin inhibitors and other anti-nutrients in soybean flour (Saxena et al, 1994). Trypsin inhibitors are responsible for inhibiting the activity of proteolytic enzymes (Feng et al, 1991).

The decrease could be caused by anti-nutrients in the substituted biscuit as the anti-nutrients interact with the protein to form complexes, which increases the degree of cross-linking, decreasing the solubility of protein and making protein complexes less susceptible to proteolytic attack, thereby adversely affecting the protein digestibility (Alonso et al, 2000).

Heat processing is reported to improve the digestibility of seed protein by destroying protein inhibitors and opening the protein structure through denaturation (Hon et al, 1977). However, heat processing can also cause a decrease in digestibility through non-enzymic browning reactions and thermal cross linking (Tannenbaum, 1974; Rooney et al, 1986).

The presence of phytic acid and polyphenols as identified with millet (Sumathai and Pattabiraman 1976) are known to associate with proteins forming insoluble complexes that could also affect the IVPD of the protein.

The sensory evaluation of the biscuit (Table 6) revealed that as the level of soybean flour was increased (0 - 30%), the crust colour of the biscuit changed from creamy to dark brown, with a decrease in the mean scores (6.1 - 4.8). However, no significant difference was observed in crust colour up to 15% blending with soybean flours, p = 0.05. Thereafter a significant difference in the crust colour was observed in all the blended biscuits. The darker crust colour may be due to Millard reaction between reducing sugar and protein (Raidi and Klevin, 1983; Dhingra and Jood, 2000).

Odour of biscuit increase (6.4 –7.2) on increasing the soybean flour up to 15% level indicating better odour rating, and thereafter it decreased at 20 and 30% level of blending. the beany flavour of soybean flavour (Grewal, 1992).

The taste score also decreased (6.2 –4.0) on increasing the level of substitution of soybean...
flours. Biscuit containing 30% soybean flour was rated poorest in taste (4.0). This might be due to the same beany-flavour of soybean (Rastogi and Singh, 1989).

The crust texture was related to the external appearance of the biscuit top, which is the smoothness or roughness of the crust. Crust texture score decreased (7.2-5.2) with increase in the substitution of soybean flour (0-30%). From the over all acceptance rating, it was concluded that biscuit up to 15% level of soybean could be baked with satisfactory performance and acceptance.

CONCLUSION

It may be inferred from the present study that soybean flour (full fat) could be added to wheat-“acha” (7:3) biscuit up to level of 15% without any significant change in organoleptic characteristics. The WAF-SBF biscuit up to this level (85:15) could provide needed nutrient to the diet because they contain high proportion of protein (11.71%), fat (21.92%), IVSD (72.9%) and IVPD (82.3%).

The economic impact of using “acha”/soybean composite flour in the manufacture of biscuit lies in the reduced need for wheat being imported. In developing countries like Nigeria, where there is a ban on wheat importation, utilization of “acha” and soybean for biscuit production should be encourage as the biscuit could be a good source of protein and energy. Biscuit consumption is high in Nigeria; therefore “acha”/soybean biscuit will serve as a vehicle for increasing intake of protein, fat and calories in Nigeria.

REFERENCES


Raidi MA, Klevin BP (1983) Effect of soy or field pea flour substitution on physical and sensory characteristics of chemistry leavened quick bread Cereal chemistry 60:367-370.

Rastogi A and Singh G (1989) Effect of addition of full fat soybean flour of different varieties in quality characteristics and bread making quality \(\ldots\)
of white flour Bulletin of Grain Technology 27:26, 34.


Table 1. Physical qualities of biscuit produced from –"acha” (AF)/soybean flour (SBF)

<table>
<thead>
<tr>
<th>Biscuit Components</th>
<th>AF:SBF</th>
<th>Width(cm)</th>
<th>Height(cm)</th>
<th>Spread Ratio</th>
<th>Average Wt.(g)</th>
<th>Break Strength(kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100:00</td>
<td>20.52± 2.3b</td>
<td>4.83± 1.2a</td>
<td>4.74± 1.9b</td>
<td>11.61± 2.4a</td>
<td>2.11± 0.8a</td>
<td></td>
</tr>
<tr>
<td>95:05</td>
<td>22.81± 1.7a</td>
<td>4.45± 1.0a</td>
<td>5.22± 1.6b</td>
<td>9.73± 2.2a</td>
<td>1.64± 0.5a</td>
<td></td>
</tr>
<tr>
<td>90:10</td>
<td>22.42 ±2.5a</td>
<td>4.43± 0.8a</td>
<td>5.23± 0.9b</td>
<td>9.61 ±1.9ab</td>
<td>1.33± 0.6ab</td>
<td></td>
</tr>
<tr>
<td>85:15</td>
<td>22.93 ±2.1a</td>
<td>4.04± 0.5ab</td>
<td>5.71 ±1.3ab</td>
<td>9.33 ±2.6b</td>
<td>1.24± 0.6b</td>
<td></td>
</tr>
<tr>
<td>80:20</td>
<td>23.13± 2.7a</td>
<td>3.72± 0.7ab</td>
<td>6.24± 1.7a</td>
<td>9.34±0.9b</td>
<td>1.14± 0.2b</td>
<td></td>
</tr>
<tr>
<td>70:30</td>
<td>23.65 ± 3.3a</td>
<td>3.51± 0.9b</td>
<td>6.73 ±1.1a</td>
<td>8.81±1.2b</td>
<td>1.13±0.34b</td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>0.85</td>
<td>-0.92</td>
<td>0.98</td>
<td>-0.96</td>
<td>-0.93</td>
<td></td>
</tr>
</tbody>
</table>

Any two means having a common letter(s) in the same column are not significantly different at the 5% level of significant

*Average of three replication

r - Correlation co-efficient

± - Standard deviation

Table 2. Proximate composition of “acha” and soybean four ( % wet basis)

<table>
<thead>
<tr>
<th>Composition (%)</th>
<th>Acha</th>
<th>Soybean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>11.91±1.3</td>
<td>7.4± 0.9</td>
</tr>
<tr>
<td>Ash</td>
<td>0.266± 0.1</td>
<td>5.1± 1.3</td>
</tr>
<tr>
<td>Protein</td>
<td>9.40± 1.1</td>
<td>39.3± 3.2</td>
</tr>
<tr>
<td>Fat</td>
<td>0.101± 0.1</td>
<td>24.5±2.5</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>72.77±4.6</td>
<td>23.2±1.6</td>
</tr>
<tr>
<td>Calorie</td>
<td>321± 8.7</td>
<td>470.5±9.6</td>
</tr>
</tbody>
</table>
Table 3. Chemical composition of biscuit produced from -acha (AF)/soybean flour (SBF) blends.

<table>
<thead>
<tr>
<th>Biscuit</th>
<th>Protein</th>
<th>Moisture</th>
<th>Fat</th>
<th>Ash</th>
<th>Carbohydrate</th>
<th>Calorie</th>
</tr>
</thead>
<tbody>
<tr>
<td>100:00</td>
<td>5.00 ±1.4c</td>
<td>2.9 ± 0.9a</td>
<td>14.80 ± 3.5e</td>
<td>9.79 ±1.4a</td>
<td>67.51 ±6.7a</td>
<td>422.34</td>
</tr>
<tr>
<td>95:05</td>
<td>6.48 ±1.4c</td>
<td>2.87 ± 0.9a</td>
<td>15.30 ± 2.7d</td>
<td>9.63 ±1.7a</td>
<td>65.72 ±8.4a</td>
<td>426.58</td>
</tr>
<tr>
<td>90:10</td>
<td>9.90 ±2.1bc</td>
<td>2.57 ± 0.4ab</td>
<td>19.94 ± 2.8c</td>
<td>9.54 ±0.9ab</td>
<td>58.05 ±6.8b</td>
<td>451.26</td>
</tr>
<tr>
<td>85:15</td>
<td>11.51 ±2.2b</td>
<td>2.47 ± 0.6ab</td>
<td>21.92 ± 2.6b</td>
<td>9.50 ±0.6ab</td>
<td>54.60 ±3.5c</td>
<td>455.52</td>
</tr>
<tr>
<td>80:20</td>
<td>12.02 ±1.6b</td>
<td>1.83 ± 0.2b</td>
<td>22.36 ± 3.1ab</td>
<td>9.41 ±1.3ab</td>
<td>54.56 ±6.9c</td>
<td>467.74</td>
</tr>
<tr>
<td>70:30</td>
<td>14.19 ±1.7a</td>
<td>1.56 ± 0.6b</td>
<td>24.01 ± 3.5a</td>
<td>9.35 ±0.8b</td>
<td>50.89 ±3.4d</td>
<td>476.41</td>
</tr>
</tbody>
</table>

R  
0.94  -0.96  0.90  -0.93  -0.95  0.97

Any two means having a common letter(s) in the same column are not significantly different at the 5% level of significant

Average of three replication

r-Correlation co-efficient

AF- Acha –wheat flour (30:70)
Table 4. Effect of baking and soybean (15%) supplementation on In-vitro protein digestibility (IVPD) of “acha”, millet and wheat Composite biscuits

<table>
<thead>
<tr>
<th>Grains</th>
<th>Unbaked</th>
<th>Baked</th>
<th>Supplemented</th>
<th>LSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Acha”</td>
<td>90.7±0.66</td>
<td>86.5±1.72</td>
<td>83.2±0.2</td>
<td>2.5</td>
</tr>
<tr>
<td>Millet</td>
<td>92.3±0.2</td>
<td>83.2±1.32</td>
<td>79.03±0.76</td>
<td>3.2</td>
</tr>
<tr>
<td>Wheat</td>
<td>93.1±0.06</td>
<td>85.2±0.75</td>
<td>82±4+0.11</td>
<td>2</td>
</tr>
<tr>
<td>LSD</td>
<td>1.2</td>
<td>2.1</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

*Mean values with difference equal to or greater than the corresponding LSD in the same column is significantly different at p=0.05
± Standard deviation

Table 5. In-vitro digestibility of biscuit produced from “acha” (AF) /soybean flour(SBF) blends

<table>
<thead>
<tr>
<th>Biscuit</th>
<th>Protein</th>
<th>Decrease in % IVPD</th>
<th>Starch</th>
<th>Decrease in % IVSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>AF:SBF</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100:00</td>
<td>89.22a</td>
<td>-</td>
<td>73.91a</td>
<td>—</td>
</tr>
<tr>
<td>95:05</td>
<td>87.13ab</td>
<td>2.09</td>
<td>73.73a</td>
<td>0.18</td>
</tr>
<tr>
<td>90:10</td>
<td>86.03ab</td>
<td>3.19</td>
<td>73.31a</td>
<td>0.6</td>
</tr>
<tr>
<td>85:15</td>
<td>82.24bc</td>
<td>6.98</td>
<td>72.94ab</td>
<td>0.97</td>
</tr>
<tr>
<td>80:20</td>
<td>80.16c</td>
<td>9.06</td>
<td>72.24ab</td>
<td>1.67</td>
</tr>
<tr>
<td>70:30</td>
<td>77.32c</td>
<td>11.9</td>
<td>71.52b</td>
<td>2.39</td>
</tr>
</tbody>
</table>

Any two means having a common letter in the same column (s) are not significantly different at the 5% level of significant
*Average of two replication
r-Correlation co-efficient
Table 6. Sensory qualities of biscuits produced from acha flour (AF) soybean flour (SBF) blends

<table>
<thead>
<tr>
<th>Qualities</th>
<th>Colour</th>
<th>Texture</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crust</td>
<td>Crumb</td>
</tr>
<tr>
<td>AF:SBF</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.53±0.98a</td>
<td>7.13±1.23a</td>
<td>6.74±0.94a</td>
</tr>
<tr>
<td>AF:SBF</td>
<td>6.42±1.02a</td>
<td>6.62±0.89a</td>
</tr>
<tr>
<td>6.61±0.67a</td>
<td>6.84±0.94a</td>
<td>6.62±0.91a</td>
</tr>
<tr>
<td>AF:SBF</td>
<td>6.83±0.68a</td>
<td>6.53±0.43a</td>
</tr>
<tr>
<td>4.91±0.34b</td>
<td>5.51±0.56b</td>
<td>5.92±0.23b</td>
</tr>
<tr>
<td>4.83±0.56b</td>
<td>4.64±0.43c</td>
<td>5.24±0.12c</td>
</tr>
</tbody>
</table>

Any two means having a common letter(s) in the same column are not significantly different at the 5% level of significant

AF:SBF – Acha flour : soybean flour ratio

± - Standard deviation