EFFECT OF pH AND TEMPERATURE ON FUNCTIONAL PHYSICO-CHEMICAL PROPERTIES OF AFRICAN YAM BEAN (SPHENOSTYLIS STENOCARPA) FLOUR

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Abstract

Brown African yam bean (Sphenostylis stenocarpa) seeds purchased from Akwata market were processed into flour. The seeds were sorted, soaked, dehulled and dried. The dried seeds were milled into flour before being defatted and processed into protein isolate (using attrition mill). Results showed that the protein isolate has a higher value of 90% and above compared with full fat and defatted flour having 22.63±0.17% and 23.57±0.17% respectively. The protein isolate has no fat and fibre with minute amount of carbohydrate of 0.34±0.11%. The result further showed that protein isolate has a good potential and finally, that pH and temperature slightly affects the functionality of full fat, defatted flour and protein isolate.

Keywords: Legumes, functional properties, African yam bean, protein, protein isolate.

INTRODUCTION

Legumes are the edible seeds of leguminous plants. Those used as food are divided into two groups, namely: the pulse and oil seed. Leguminous plants play an important role in human nutrition. They provide a significant amount of food in developing countries. They along with cereals, roots and vegetables constitute the staple foods that are consumed. Studies have shown that foods of plant origin are capable of contributing appreciable quantities of nutrients including protein, needed by both children and adults if properly processed and blended.

Leguminous seeds are important sources of protein energy and other nutrients in the diet of large population groups around the world forming an excellent source of thiamine and contributing appreciable quantities of the other water soluble vitamins (riboflavin, niacin and pyridoxine) and of the minerals (phosphorus, iron, calcium and magnesium). Legumes have been underutilized because of the presence of anti-nutritional factors such as enzymes (trypsin, chymotrypsin, α-amylase) inhibitors, phytic acid, flatulence factors, saponins and toxic factors and the need for prolong cooking. These factors negatively affect the nutritive value of beans through direct and indirect reactions. They inhibit protein and carbohydrate digestibility, induce pathological changes, inhibit a number of enzymes and bind nutrients making them unavailable.

The quality attributes of food products developed from legume flour samples are generally affected by the functional properties of the flour which are influenced by the processing conditions employed. Emulsifying and foaming characteristics of protein contribute much to the functionality of food. Functional properties are influenced by pH, temperature and heat treatment. Protein deficiency is the prevalent form of malnutrition in many countries. One of the ways is to increase the protein supply to make plant protein available for human consumption and develop the production of unconventional protein for foods. The search for nutritional balanced foods to make available to a substantial proportion of the population has stimulated investigation into unusual sources of protein. Indeed, protein isolate has been extensively studied as food and dietary supplements for several oil seeds such as sesame, soy beans and castor seed.

Many proteins occur in cell conjugated with lipid, carbohydrate and other molecules. The easiest method of separating protein from cellular structure of the seed is by extracting with aqueous solvent for successful utilization of food products, however the protein should posses a high degree of functionality which is governed by four factors; colour flour texture and nutritive value.

There is little or no information on the chemical
composition of African yam bean and functionality of protein isolate. This study was therefore undertaken to provide information on the proximate composition, functional properties of full fat, defatted flour and protein isolate inducing the effect of pH and temperature on some of their functionality of flour from the seed of AYB bean grown in Nigeria.

MATERIAL AND METHODS
The brown (dark coloured) African yam bean (Shpenostyli stenocarpa) used for the work was purchased from Akwata market Enugu state, Nigeria. All the chemicals and equipment were sourced from central laboratory service unit of National Root Crops Research Institute (NRCRI) Umudike, Umuahia.

PREPARATION OF SAMPLES
Prior to defatting and isolation of protein, African yam beans were processed. First, the beans were sorted manually to remove extraneous materials like dirt residue and diseased seeds to obtain healthy ones. The selected seeds were then soaked for 24 hours, dehulled and dried in hot air oven at 55°C for 12 hours. The dried seeds were milled with locally fabricated attrition mill to obtain fine flour for analysis. Then the three samples which are full fat flour, defatted flour and protein isolate were obtained.

PROXIMATE COMPOSITION
The flour samples were analyzed for protein, ash, crude fibre, fat, carbohydrate and moisture content. Protein content was determined using kjeldahl method and nitrogen content of the samples was multiplied by a factor, 6.25. Crude fibre, moisture content and ash content were determined using the method of 9 carbohydrate was calculated by difference 10.

FUNCTIONAL PROPERTIES
The functional properties of African yam bean flour samples were determined using the method specified by 11,12,13

STATISTICAL ANALYSIS
Experimental data obtained from proximate composition and functional properties of flour samples from African yam bean seeds were subjected to statistical analysis using analysis of variance (ANOVA). Means and standard variations of triplicate data were also determined 14.

RESULT AND DISCUSSION
PROXIMATE COMPOSITION
Table 1 presents the proximate composition of flour samples. The result revealed a high protein content of 22.63±0.17% of flour. 15 reported a protein content of 21.0-29.0% for AYB full fat flour, although lower than most major legumes like soy bean (38-44%), African locust bean (23-27%) and was found to be higher than most other legumes including bambara groundnut (21-26%). On the other hand, results showed that the AYB protein isolate had an average protein content of 90.37%. This compared favourably with (81-91%) obtained for winged bean and 96.5% for the soy bean 12. The ash content of the protein isolate is 3.07± 0.04% was found to be higher than the value obtained from AYB 2.07 ± 0.04% by 15. However, it was lower than the values obtained for other legumes. Soybean isolate 3.4% and winged bean protein isolate (5.5-7.5%) 12.

FUNCTIONAL PROPERTIES
The functional properties of the full fat flour, defatted flour and protein isolate are shown in table II below. The result showed relatively high bulk density. The bulk density of the isolate, indicate a high volume per gram of the protein material and this is reportedly important in relation to its packaging. 16. Soy bean isolate was reported to have a bulk density (0.619 g/m 3).

The absorption capacity of protein isolate was significantly higher than that of full fat flour and the defatted flour, the oil binding capacity of protein materials are important factor which determines how well the material will perform as meat extender or analogue as observed by 17.
Table 1: Proximate composition of AYB flour, defatted flour and protein isolate.

<table>
<thead>
<tr>
<th>Samples</th>
<th>Protein</th>
<th>Fat</th>
<th>Fibre</th>
<th>Ash</th>
<th>Moisture</th>
<th>Carbohydrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full fat flour</td>
<td>22.63a</td>
<td>6.15a</td>
<td>2.32b</td>
<td>2.25c</td>
<td>6.95a</td>
<td>59.70b</td>
</tr>
<tr>
<td>±0.17</td>
<td>±0.03</td>
<td>±0.01</td>
<td>±0.01</td>
<td>±0.01</td>
<td>±0.01</td>
<td>±0.14</td>
</tr>
<tr>
<td>Defatted flour</td>
<td>23.57b</td>
<td>0.57b</td>
<td>2.85a</td>
<td>2.77b</td>
<td>6.70b</td>
<td>63.51a</td>
</tr>
<tr>
<td>±0.17</td>
<td>±0.01</td>
<td>±0.01</td>
<td>±0.05</td>
<td>±0.02</td>
<td>±0.19</td>
<td>±0.19</td>
</tr>
<tr>
<td>Protein isolate</td>
<td>90.57a</td>
<td>0.00c</td>
<td>0.00c</td>
<td>3.07a</td>
<td>6.02c</td>
<td>0.34c</td>
</tr>
<tr>
<td>±0.12</td>
<td>±0.00</td>
<td>±0.00</td>
<td>±0.04</td>
<td>±0.02</td>
<td>±0.11</td>
<td>±0.11</td>
</tr>
<tr>
<td>LSD</td>
<td>0.513</td>
<td>2.73</td>
<td>0.350</td>
<td>0.124</td>
<td>0.156</td>
<td>0.532</td>
</tr>
</tbody>
</table>

All values are expressed as mean ± SD of three determinations. Mean values within column with different superscripts are significantly different at ≤0.05.

Table 2: Functional properties of AYB flour, defatted flour and protein isolate.

<table>
<thead>
<tr>
<th>Samples</th>
<th>BD</th>
<th>SWI</th>
<th>WAC</th>
<th>OAC</th>
<th>FC</th>
<th>EC</th>
<th>W</th>
<th>GT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full fat flour</td>
<td>0.667b</td>
<td>1.25c</td>
<td>2.10c</td>
<td>1.68c</td>
<td>7.18b</td>
<td>85.07a</td>
<td>1.37b</td>
<td>82.0a</td>
</tr>
<tr>
<td>±0.00</td>
<td>±0.04</td>
<td>±0.08</td>
<td>±0.04</td>
<td>±0.92</td>
<td>±0.09</td>
<td>±0.05</td>
<td>±0.82</td>
<td></td>
</tr>
<tr>
<td>Defatted flour</td>
<td>0.668a</td>
<td>1.35b</td>
<td>3.37b</td>
<td>3.08b</td>
<td>11.05a</td>
<td>92.6a</td>
<td>50.30a</td>
<td>84.0a</td>
</tr>
<tr>
<td>±0.011</td>
<td>±0.05</td>
<td>±0.04</td>
<td>±0.75</td>
<td>±0.75</td>
<td>±0.75</td>
<td>±0.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein isolate</td>
<td>0.619c</td>
<td>2.73a</td>
<td>4.77a</td>
<td>3.99a</td>
<td>5.35b</td>
<td>35.8b</td>
<td>3.67b</td>
<td>Nil</td>
</tr>
<tr>
<td>±0.009</td>
<td>±0.05</td>
<td>±0.05</td>
<td>±0.50</td>
<td>±0.955</td>
<td>±0.97</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSD</td>
<td>0.003</td>
<td>0.142</td>
<td>0.210</td>
<td>0.144</td>
<td>2.262</td>
<td>12.20</td>
<td>2.274</td>
<td></td>
</tr>
</tbody>
</table>

All values are expressed as mean ± SD of three determinations. Mean values within column with different superscripts are significantly different at ≤0.05.

Where: BD= Bulk density (g/cm³), SWI= Swelling index (g/cm), WAO= Water absorption capacity (g/mls), OAC= Oil absorption capacity (g/mls), FC= Foaming capacity (%), EC= Emulsion capacity (%), W=Wettability (sec), GT= Gelling temperature (°C)

Fig 3: The effect of temperature on water absorption of full fat, defatted flour and protein isolate

Fig 4: The effect of temperature on swelling index of full fat, defatted flour and protein isolate

Fig 5: The effect of temperature on foaming capacity of full fat, defatted flour and protein isolate.

Fig 6: The effect of pH on water absorption of full fat, defatted flour and protein isolate.
head functional properties of AYB-Vigna significantly lower than that of full fat flour and those of full fat (9.18%) and 19 kα, A. -

Fig. 7: The effect of P on swelling index of full fat, defatted flour and protein isolate

Fig. 8: The effect of P on foaming capacity of full fat, defatted flour and protein isolate

The foaming capacity of AYB protein isolate was 5.23% and was significantly lower than that of full fat flour and the defatted flour. The oil binding capacity of protein material is an important factor which determines how well the material will perform as meat extender or analogue as observed by 17. AYB protein isolate was 5.23% and was significantly lower than those of full fat (9.18%) and defatted flour (11.05%). Foaming characteristics of flour or protein isolate depends on the ability to, when whipped to maintain the whip for as long as possible 18. The ability to retain stable froth makes an agent a useful material for the production of food with long lasting foam such as ice cream. Against the above background, AYB protein isolate could find utilization as protein enhancer enhancing ice cream for higher nutritional values. The emulsion capacity of the isolate are found to be 35.8% and comparatively lower than the full fat and defatted flour. The relatively low emulsion capacity of the isolate could be due to the nature and the type of protein. 19, reported that emulsion capacity and stability is higher on protein with globular nature. Also, the isolate was found with a wettability time of 3.67 seconds per gram. The low gelling concentration obtained on this study for protein isolate could be attributed to high protein content of the flour. The result obtained here was partly in agreement with report of 20 on a cowpea variety in Sudan.

EFFECT OF pH
The result shown in figure 8 revealed that the foaming capacity increased with increasing pH for the full fat and the protein isolate, foaming capacity revealed optimum levels at pH 12.0 and 6.0 respectively whereas defatted flour increased linearly. The ability of protein to form stable foam was reported to depend on may factors some of which include calcium ions, pH, temperature, degree of denaturation, protein type and whipping methods 20. The increase in foaming of AYB flours and protein isolate as obtained in this work, agree with recent works in the protein isolate of wheat. Figure 7 showed that the swelling index decreases in the alkaline range 4.5-60. The pH is reported to affect protein solubility 12 and protein solubility is known to be a critical functional property which influences other properties like foaming, emulsification and gelation 16. The water absorption capacity of the flour and protein isolate as shown and also affected by pH and increased to the maximum at pH 10 and declined.

EFFECT OF TEMPERATURE
The effect of temperature change on the functional properties of AYB flour and isolate are shown in figure 3-5. The result showed a contrast to that of pH. The water absorption decreased steadily with increasing temperature from 30 °c to 60 °c. Similarly, the foaming capacity decreased with increasing temperature while the swelling index increased. The changes in functional properties due to temperature change aggress with earlier report which observed temperature as one of the initial factor which affects functional properties of flours and protein isolate.

CONCLUSION
The result from analysis revealed great potential good uses of African yam bean. The protein isolate was found to be very high in protein content, this making it a potential source of quality protein material use in food industry. The physico - chemical and functional properties of AYB protein isolate exhibited is comparable with those of other legumes such as soy bean and wing bean. There is therefore the possibility of AYB contributing positively to supplement if not replace protein materials from animal source especially giving the high cost of animal protein in developing county.

It is therefore concluded that AYB represents a source of alternative protein supplement. Protein isolates also posses’ characteristics which show that it could find its uses in the different products as protein enrichment or texturizer.

REFERENCES
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