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# EFFECT OF PROCESSING ON DIETARY FIBRE, PROXIMATE AND FUNCTIONAL PROPERTIES OF SOYBEAN (*Gyycine max. mer.*) AND AFRICAN YAM BEAN (*Sphenostylis stenocarpa*) FLOUR SAMPLES.

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## ABSTRACT

The effects of toasting (l0 and 15 minutes), soaking (12 and 24 hours) and boiling (20 and 30 minutes) on the dietary fibre content, proximate composition and functional properties of soybean flour (SF) and African yam bean flour (AYBF) samples were studied. Dietary fibre composition of SF comprised 4.62 - 3.40 %, 8.57 % - 5.75 % and 12.52% - 10.43 % for soluble, insoluble and total dietary fibre (TDF) respectively, while that of AYBF comprised 5.47 % - 3.28 %, 11.64 % - 8.71 % and 16.62 % - 12.28 % for soluble, insoluble and TDF. The proximate composition of SF comprised 12.02 % - 9.14 %, 29.00 % - 5.18 %, 29.86 % - 17.68 %, 29.57 % - 19.91 %, for moisture, fat, protein and carbohydrate content, while in AYBF, 9.27 % - 5.00 %, 17.00 % - 7.00 %, 23.53 % - 14.22 %, 55.83 % - 51.97 % for moisture, fat, protein and carbohydrate content. The functional properties of SF ranged from 2.49 g/ml - 1.80 g/ml for oil absorption capacity (OAC), 4.50 g/ml - 2.94 g/ml for water absorption capacity (WAC), 86.67°C - 77.00°C for gelation temperature (GT), while that of AYBF comprised, 21.4 g/ml - 1.68 g/ml (OAC), 3.44 g/ml - 2.10 g/ml (WAC), and 82.00°C - 75.00°C (GT). Conclusively, processing had significant effects on the dietary fibre composition, proximate composition, and the functional properties of SF and AYBF with toasting being discovered to increase significantly their IDF and TDF.

**Keywords:** African yam bean, Dietary fibre, Processing, Proximate analysis, Soybean.

## 1. INTRODUCTION

Dietary fibre is one of the recognized food constituents with beneficial capabilities [37]. It contains polymeric non-starch substances, capable of resisting enzymatic digestion in the intestine. Also, dietary fibre contains complex carbohydrates like cellulose, hemi-cellulose, and pectin [32], as well as phenolic compound and lignin [18]. A diet rich in dietary fibre can be

  

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beneficial in reducing body fat and triglycerides in individuals with cardiovascular health challenges. Thus, regular consumption of fibre rich foods tends to lower the risk of cardiovascular disease [14]. Soybean and African yam bean are important legumes with significant quantity of dietary fibre, which makes them beneficial in blood cholesterol triglycerides regulation [22]. For these reasons, raw fibre is being largely introduced into food formulation for improved health. However, the constituents that make up the total fibre composition may be significantly affected by different processing techniques, which may in turn affect physiological effects to good health [2].

Soybean (*Glycine max. mer*.) is appreciably rich in cheap and high-quality protein (36 %). Comparable to meat, poultry and eggs, soybean is readily available to the poor and low-income earners. They contain important vitamins and minerals, riboflavin, omega-3 fatty acids, copper, manganese, molybdenum and potassium. Consistently, there has been a moderate reduction of low-density lipoprotein cholesterol associated with soybean intake [17]. More so, about 20 % of oil can be found in soybean seed, making it an essential and important oil-bearing seed.

African yam bean (AYB) (*Sphenostylis stenocarpa*) is underutilize and less known compared to other major legumes in the tropics [19]. African yam bean is pronouncedly cultivated in Nigeria [30]. AYB is more grown in the Southern [33] part of Nigeria because of the conducive growth, however, extensive cultivation has been reported in the eastern [1] and western Nigeria [31]. African yam bean contains a protein content of approximately 21 % and can rise up to 30 % depending on the variety and growing condition as well as soil characteristics. Depending on the region and tradition of the people, AYB can be referred to different names in Nigeria, for instance, as “Odudu” in Igbo language, “Sese” in Yoruba language, “Girgiri” in Hausa language and many more in different parts of the country. [9]. Legumes are usually subjected to different processing techniques because of the presence of anti-nutrient before consumption but the information on their effect on dietary fibre is limited. More so, sufficient research has not been carried out on dietary fibre contents of most locally processed flour samples and the effects of processing on their dietary fibre. Understanding the effects of processing on dietary fibre, proximate and functional properties of soybean and African yam bean flour samples was the basis for this study.

## 2. MATERIALS AND METHODS

### 2.1 Source of raw materials

African yam bean and Soybean were purchased from Umuahia main market Ubani, Abia state.

### 2.2 Production of soybean into different flour samples

  

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The soybean flour was produced according to the method of Sowonola *et al.* [34] and Olaoye [25] with slight modifications. The soybeans were cleaned and sorted for defects. A portion of raw soybeans were milled and sieved into fine flour. Furthermore, some cleaned soybeans were divided into three different portions and was subjected to three different processing methods at two distinct times, respectively. Firstly, 300 g of soybean seeds were toasted for 10 minutes and 15 minutes at 85°C respectively. After which, they were cracked, dehulled, milled, sieved into fine flour, packaged with airtight cellophane bag and stored prior to analysis. Secondly, 300 g of soybean seed were soaked in 1000 ml of distilled water for 12 hours and 24 hours followed by dehulled manually and washing and rinsing severally with tap water. They were oven-dried at 65°C and then milled, sieved, packaged with airtight cellophane bag and stored prior to analysis. Thirdly, 300 g of soybean seeds were boiled for 20 minutes and 30 minutes respectively. After which, they were dehulled manually, rinsed thoroughly with clean water, oven-dried, milled, sieved, packaged with airtight cellophane bag, and stored until required for analysis.

**2.3 Production of African yam bean into different flour samples**

The African yam bean flour was produced according to the method of Ishimu and Onyeji [15] with slight modifications. The African yam bean seeds were cleaned and sorted. A portion of raw sample was milled and sieved into fine flour. Thereafter, some quantity of the already cleaned sample was divided into three different portions and was subjected to three different processing methods at two distinct times, respectively. The first portion was divided into two different portions; they were toasted for 10 minutes and 15 minutes at 85°C respectively, and were cracked, dehulled, milled, sieved, packaged with an airtight cellophane bag, and stored until required for analysis. The second portion was divided into two different portions, and were soaked in 2 litres of water, for 12 hours and 24 hours respectively. The seeds were dehulled, washed and rinsed with clean water, followed by oven-drying at 65°C, milled, sieved, packaged with airtight cellophane bag and stored until required for analysis. The third portion was divided also into two different portions, they were boiled with clean water for 20 minutes and 30 minutes respectively. After which, they were dehulled, rinsed with clean water, oven-dried, milled, sieved and packaged with an airtight cellophane bag. Then, they were stored until required for analysis.

**2.4 Sample analyses**

Samples were subjected to dietary fibre analysis, proximate and functional analysis. Table I present the codes representing each sample.

**2.5 Dietary fibre analysis**

Dietary fibre was determined using enzymatic gravimetric method of AOAC [10].

**2.6 Functional analysis**

  

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The method of Okaka and Potter [23] was used to determine bulk density. The method of Onwuka [28] was used to determine foam capacity, wettability, gelatinization temperature, oil absorption capacity, emulsion capacity, water absorption capacity and swelling index.

### 2.7 Proximate analysis

Moisture content was carried out by the method of AOAC [10]. Ash content, crude fibre content and carbohydrate content was determined by the method described by James [16]. Fat determination was carried out as described by Pike [29]. Crude protein was analysed by the Kjeldahl method described by Change [12].

### 2.8 Statistical analysis

All experimental data were expressed as mean ± SD (standard deviation). The data were subjected to a normality check, followed by Levene's test for homogeneity of variance. The pre-requisites test fulfilled the assumption of using one-way analysis of variance (ANOVA) to analyse the data by the SPSS software (version 16, IBM, USA, while the Duncan Multiple Range Test method was used to compare the means of experimental data at 95 % confidence interval when a significant difference was observed from the One-way ANOVA.

**Table 1: Codes representing each flour sample.**

| Samples | Codes |
|---|---|
| Raw soybean flour | RSF |
| 10 minutes toasted soybean flour | TSF10min |
| 15 minutes toasted soybean flour | TSF15min |
| 12 hours soaked soybean flour | SSF12h |
| 24 hours soaked soybean flour | SSF24h |
| 30 minutes boiled soybean flour | BSF30min |
| 20 minutes boiled soybean flour | BSF20min |
| Raw African yam bean flour | RAYBF |
| 10 minutes toasted African yam bean flour | TAYBF10min |
| 15 minutes toasted African yam bean flour | TAYBF15min |
| 12 hours soaked African yam bean flour | SAYBF12h |
| 24 hours soaked African yam bean flour | SAYBF24h |
| 20 minutes boiled African yam bean flour | BAYBF20min |
| 30 minutes boiled African yam bean flour | BAYBF30min |

  

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## 3. RESULTS AND DISCUSSIONS

### 3.1 Dietary fibre composition

The dietary fibre composition of processed soybean and African yam bean flour samples are shown in Table II and Table III respectively. The effects of processing had significant influence on the dietary fibre composition of the flour samples. With respect to soybean flour, RSF had the lowest soluble dietary fibre (SDF) value (3.40 %). More so, the processing time of each unit operation affected the SDF. The longer the processing time, the higher the SDF, for instance, SSF12h had lower value (3.64 %) compared to SSF24h (3.77 %). Furthermore, boiled samples such as BSF20min and BSF30min had the highest SDF values of 4.41 % and 4.62 % respectively, which implied that boiling increased the SDF of soybean flour more than toasting and soaking. In terms of African yam bean flour, boiling operation decreased the SDF the most from 4.93 % (RAYBF) to 3.87 % (BAYBF20min) and further boiling for 30 minutes (BAYBF30min) decreased the SDF more to 3.28 %. Toasting for 10 minutes (TAYBF10min) significantly increased the SDF from 4.93 % (RAYBF) to 5.36 % while toasting for monger time such as 15 minutes (TAYBF15min) decreased the SDF to 4.93 %. Similar trend was also observed in the soaking operation. This suggested that toasting and soaking operations for a relatively short time, increased the SDF level of AYBF. Insoluble dietary fibre (IDF) of toasted soybean flour increased, however, there was no significant difference ($p < 0.05$) between TSF10min (8.56 %) and TSF15min (8.57 %). Soaking operation reduced the IDF while boiling operation reduced the IDF of soybean flour the most, precisely from 8.03 % (RSF) to 6.17 % (BSF20min) and 5.75 % (BSF30min) respectively. Similar trend was also observed for African yam bean flour. Thus, comparing all samples to the control, toasting was found to increase significantly ($P<0.05$) IDF of soybean and African yam bean flour samples. The reduction in IDF of these legumes after boiling treatments was also observed by other investigators [36]. However, Thed *et al.* [35] reported an increase in IDF of boiled and microwaved mung bean. They linked this outcome to the development of substances similar to lignin or to resistant starch. Relative to total dietary fibre (TDF), Boiling for (20 minutes and 30 minutes), caused a significant ($p<0.05$) reduction of TDF in soybean and African yam bean flour samples, comparing to raw samples. While, toasting at 85ºC for (10 minutes and 15 minutes) significantly ($p<0.05$) increased TDF of soybean and African yam bean flour samples, while soaking operation values were not too different from those of raw samples for both soybean and African yam bean flours. The results indicated that different treatments resulted in different effects on dietary fibres of food samples.

  

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**Table II: Dietary fibre composition of Soybean flour samples.**

| Sample codes | Soluble dietary fibre (SDF) (%) | Insoluble dietary fibre (IDF) (%) | Total dietary fibre (TDF) (%) |
|---|---|---|---|
| RSF | $3.40^{f}$±0.14 | $8.03^{b}$±0.18 | $11.43^{d}$±0.04 |
| TSF10min | $3.82^{c}$± 0.03 | $8.56^{a}$ ± 0.64 | $12.38^{b}$ ± 0.04 |
| TSF15min | $3.96^{c}$± 0.02 | $8.57^{a}$ ± 0.13 | $12.52^{a}$ ± 0.11 |
| SSF12h | $3.64^{e}$± 0.02 | $7.85^{b}$± 0.05 | $11.48^{d}$ ± 0.03 |
| SSF24h | $3.77^{d}$± 0.02 | $7.96^{b}$± 0.01 | $11.73^{c}$ ± 0.04 |
| BSF20min | $4.41^{b}$± 0.01 | $6.17^{c}$ ± 0.05 | $10.58^{e}$ ± 0.04 |
| BSF30min | $4.62^{a}$± 0.03 | $5.75^{d}$± 0.01 | $10.43^{f}$ ± 0.04 |
| LSD (0.05%) | 0.06 | 0.01 | 0.06 |

Mean values down the columns with different letters are significantly different ($P < 0.05$).

**Table III: Dietary fibre composition of African yam bean flour samples.**

| Sample codes | Soluble dietary fibre (SDF) (%) | Insoluble dietary fibre (IDF) (%) | Total dietary fibre (TDF) (%) |
|---|---|---|---|
| RAYBF | $4.93^{b}$±0.04 | $10.25^{c}$±0.07 | $15.18^{d}$±0.04 |
| TAYBF10min | $5.36^{a}$±0.03 | $11.26^{b}$±0.14 | $16.62^{a}$±0.11 |
| TAYBF15min | $4.93^{b}$±0.04 | $11.64^{a}$±0.19 | $16.56^{a}$±0.22 |
| SAYBF12h | $5.47^{a}$±0.18 | $9.96^{c}$ ± 0.23 | $15.43^{c}$±0.04 |
| SAYBF24h | $5.09^{ab}$±0.41 | $10.16^{c}$±0.23 | $15.83^{b}$±0.04 |
| BAYBF20min | $3.87^{c}$± 0.03 | $8.71^{d}$ ± 0.06 | $12.58^{e}$±0.03 |
| BAYBF30min | $3.28^{d}$± 0.04 | $9.00^{d}$± 0.00 | $12.28^{f}$±0.04 |
| LSD (0.05%) | 0.11 | 0.20 | 0.26 |

Mean values down the columns with different letters are significantly different ($P < 0.05$).

### 3.2 Proximate composition

The proximate composition of processed soybean and African yam bean flour samples are shown in Table IV and Table V respectively. The moisture content of toasted soy bean flour samples and African yam bean flour samples was lower compared to other samples. However, TSF15min (9.28 %) and TAYBF15min (6.00 %) had higher moisture content than TSF10min (9.14 %) and TAYBF10min (5.00 %). Soaking operation resulted to flour samples with the highest moisture content. Soaking for longer time (SSF24h and SAYBF24h) resulted to the highest moisture content (12.02 % and 9.00 %). Although, the moisture contents of the flour samples were generally moderate which implied good stable shelf life if appropriately packaged and stored. However, toasting resulted to having the highest reduction in the moisture content of both soybean and African yam bean flour samples. This indicates that the flour is better preserved by toasting compared to other treatment [11]. The ash content of TSF15min was the highest (10.50 %) and while RSF had the lowest value (5.00 %). Comparing the processed flour samples to the raw sample (RSF), toasting, soaking and boiling increased the ash content of the soybean flour samples, which signified that processing improved the mineral availability of soybean [27]. However, toasting and soaking increased the ash content of the African yam bean (AYB) flour samples while, boiling decreased the ash content. Protein content was highest in RSF (29.86 %) and lowest in BSF20min (17.68 %). It was observed that the crude protein of the processed soybean flour was lower than that of the flour from the raw. Particularly, boiled samples of soybean flours had the lowest protein content while those subjected to soaking operation (SSF12h and SSF24h) had a protein content (27.68 % and 28.15 %) close to those of the raw samples.

Similar to soy bean flours, crude protein for unprocessed AYB flour was significantly higher than the processed AYB flour samples. The results obtained in this study showed that the protein content of food samples is significantly reduced upon heat treatment such as toasting and boiling and less affected by soaking unit operations. The fat content of both soybean flours and African yam bean flours showed that, those that were subjected to boiling operations had the highest fat content. More so, longer processing time in toasting and boiling unit operations for both soybean and AYB flour samples resulted to increased fat content, while the raw samples had the lowest fat content which will be of advantage in terms of storability. However, the level of the fat content in soaked samples were significantly lower than the raw, boiled and the toasted samples. The fat content of a food sample can affect its shelf life stability. This is because fat undergo oxidative deterioration which leads to rancidity and spoilage [8]. The crude fibre content denoted the proportion of complex carbohydrate in a food sample. The amount of crude fibre in soybean flour samples varied significantly ($p<0.05$) among the samples. Notably, the crude fibre content of toasted samples was significantly higher than other samples, followed by soaked samples, while those of raw samples and boiled samples were closely related. In terms of African yam bean (AYB) flour, all processing steps increased the crude fibre content of the flour samples. Toasting operation had the highest incremental effect while RAYBF had the lowest crude fibre value (2.32 %). Therefore, toasting operations was seen to increase the crude fibre content of both soybean and AYB flour samples. Carbohydrate was highest in sample BSF30min (29.57%) and lowest in SSF24h (19.91%) in soybean flour samples. The level of carbohydrate in processed AYB flour samples was significantly higher than that in the unprocessed AYB. Agiang *et al.* [4], reported that cooking disintegrates the granules, improve the imbibation of water into the

  

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cellulose and softens it and ultimately improves the bioavailability of starch. This could be the reason the processed samples had improved carbohydrate content. Furthermore, it was observed that, processing for shorter time such as 10 minutes (toasting), 12 hours (soaking), 20 minutes (boiling) seems to increase the carbohydrate content of the AYB flour samples.

**Table IV: Proximate composition of processed soybean flour samples.**

| Sample Codes | Moisture (%) | Ash (%) | Fat (%) | Fibre (%) | Protein (%) | CHO (%) |
|---|---|---|---|---|---|---|
| RSF | $11.0^{b}$ ±0.20 | $5.00^{a}$ ± 0.20 | $20.0^{c}$ ± 0.20 | $5.30^{f}$ ±0.02 | $29.86^{a}$ ±0.02 | $28.84^{b}$± 0.02 |
| TSF10min | $9.14^{f}$ ± 0.02 | $9.00^{b}$ ± 0.20 | $23.93^{c}$ ± 0.12 | $9.57^{b}$±0.02 | $24.45^{d}$ ±0.02 | $23.84^{d}$ ± 0.02 |
| TSF15min | $9.28^{e}$ ± 0.02 | $10.50^{d}$ ± 0.02 | $25.94^{a}$± 0.12 | $9.70^{a}$ ±0.02 | $22.70^{e}$ ±0.02 | $21.81^{f}$ ±0.02 |
| SSF12h | $11.89^{a}$ ± 0.02 | $9.50^{c}$ ± 0.02 | $21.00^{b}$ ± 0.20 | $6.51^{d}$ ±0.02 | $27.68^{c}$ ±0.02 | $23.42^{e}$ ±0.02 |
| SSF24h | $12.02^{a}$ ± 0.02 | $10.30^{d}$ ±0.02 | $23.00^{a}$ ± 0.20 | $6.62^{c}$ ±0.02 | $28.15^{b}$ ±0.02 | $19.91^{g}$ ±0.02 |
| BSF20min | $10.18^{d}$± 0.02 | $10.17^{d}$ ±0.57 | $29.00^{a}$ ±0.20 | $5.72^{e}$ ±0.02 | $17.68^{g}$ ±0.02 | $26.92^{c}$ ±0.02 |
| BSF30min | $10.32^{c}$± 0.02 | $9.50^{c}$ ±0.02 | $27.00^{b}$ ±0.20 | $5.18^{g}$ ±0.02 | $18.43^{f}$ ±0.02 | $29.57^{a}$ ±0.02 |
| LSD (0.05%) | 0.13 | 0.13 | 0.93 | 0.11 | 0.47 | 0.42 |

Mean values down the columns with different letters are significantly different ($P < 0.05$).

  

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**Table V: Proximate composition of processed African yam bean flour samples.**

| Sample Codes | Moisture (%) | Ash (%) | Fat (%) | Fibre (%) | Protein (%) | CHO (%) |
|---|---|---|---|---|---|---|
| RAYBF | 9.27$^{a}$ ±0.02 | 3.27$^{d}$ ±0.02 | 9.51$^{e}$ ±0.25 | 2.32$^{g}$ ±0.02 | 23.53$^{a}$±0.02 | 51.97$^{g}$ ±0.02 |
| TAYBF10min | 5.00$^{f}$ ±0.20 | 3.50$^{ed}$ ±0.02 | 14.00$^{d}$±0.20 | 5.58$^{b}$ ±0.02 | 16.32$^{e}$±0.02 | 55.60$^{b}$ ±0.02 |
| TAYBF15min | 6.00$^{e}$ ±0.20 | 3.80$^{bc}$ ±0.02 | 15.00$^{c}$±0.20 | 5.72$^{a}$±0.02 | 16.41$^{d}$±0.02 | 53.07$^{e}$ ±0.02 |
| SAYBF12h | 8.80$^{b}$ ±0.02 | 4.00$^{b}$ ±0.20 | 7.00$^{g}$±0.20 | 4.09$^{f}$±0.02 | 20.28$^{c}$±0.02 | 55.83$^{a}$ ±0.02 |
| SAYBF24h | 9.00$^{b}$ ±0.20 | 4.50$^{a}$ ±0.02 | 8.00$^{f}$±0.20 | 4.38$^{e}$ ±0.02 | 21.77$^{b}$±0.02 | 52.35$^{f}$ ±0.02 |
| BAYBF20min | 7.00$^{d}$ ±0.20 | 2.50$^{e}$ ±0.02 | 16.00$^{b}$±0.20 | 5.02$^{ce}$ ±0.02 | 14.22$^{g}$±0.02 | 55.26$^{c}$ ±0.02 |
| BAYBF30min | 8.20$^{c}$ ±0.02 | 2.33$^{e}$ ±0.42 | 17.00$^{a}$±0.20 | 4.87$^{d}$ ±0.02 | 14.81$^{f}$ ±0.02 | 53.12$^{d}$ ±0.02 |
| LSD (0.05%) | 0.20 | 0.17 | 1.00 | 0.14 | 0.09 | 0.05 |

Mean values down the columns with different letters are significantly different ($P < 0.05$).

### 3.3 Functional properties

The functional properties of processed soybean and African yam bean flour samples are shown in Table VI and Table VII respectively. Oil absorption capacity (OAC) is attributed mainly to the physical entrapment of oil [13]. The results showed that the oil absorption capacity (OAC) of soybean flour sample increased significantly with boiling and toasting but decreases with soaking. This possible suggest that heating operations increased the OAC of soybean flours. Similar to soybean flours, toasting and boiling had more pronounced effect on OAC than soaking in AYB flour samples. However, the OAC of soybean and AYB flours are quite low. Adebowale and Lawal [3], reported that differences in the proportion of non-polar side chains that capable of attaching to the hydrocarbon side chains of oil, explains the behaviour of different flour exhibiting different oil binding capacity. Hence, the lower OAC of the raw and processed soybean and AYB flour samples can be linked to lower amount of hydrophobic proteins when compared to other flour samples [24]. The water Absorption Capacity (WAC) in soybean flour samples reduced significantly with processing such that the RSF had the highest value (4.50 g/ml) while the processed samples had values that ranged from 2.94 to 3.28 g/ml. However, the WAC value of the raw and processed soybean flour samples was comparatively within the range (3.00 - 5.00 g/ml) reported by Akinyede and Amoo [6]. In contrast to the results obtain for soybean flours, the WAC in AYB flour samples increased with processing such that boiling operation, particularly boiling for 30 minutes (BAYBF30min) (3.44 g/ml) resulted to increased WAC of the AYBF samples. Water absorption capacity indicate how efficiently the incorporation of protein into aqueous food formulations can be [20]. The implication of this property is that, it allows food manufacturers, particularly confectionery industries, to propagate the extent to which water can be added to dough for improve handling and freshness [21]. It is

  

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very beneficial in baked products where hydration is required to improve the quality of handling [13]. Thus, processed soybean and AYB flour may find use as functional ingredient in soups, gravies and baked products. Akubor and Badifu [7] reported that foam capacity (FC) of flour samples, can be reduced by thermal processing which is similar to what was obtained in the present study. The foam capacity (FC) of the soybean flour samples was significantly reduced after toasting operation. However, the boiling and soaking operations had values comparable to the raw samples. This means that toasting reduced surface tension by inhibiting the presence of flexible protein molecules [6], as a consequence, reducing the foaming capacity. In AYB flour samples, boiling, toasting, and soaking had no significant effect on the foam capacity. Bulk density (BD) is defined as the mass/volume of a substance. It reveals how porous a product is which is an important determinant in the design and requirement of packaging materials, since it reveals the load carrying capacity of a food material when allowed to rest on its weight [26]. The (BD) of soybean flour ranged from 0.43 g/ml to 0.61 g/ml. The BD increased significantly after 15 minutes of toasting (TSF15min) (0.61 g/ml), but no significant difference was observed in other processed samples and the raw sample which suggested similar packaging requirements. The BD of African yam bean (AYB) flour sample ranged from 0.61 g/ml to 0.86 g/ml. Soaking operations (SAYBF12h and SAYBF24h) increased the BD value (0.86 g/ml and 0.71 g/ml) the most over other unit operations while boiling for 20 minutes (BAYBF20min) resulted to a significant reduction in the bulk density of the AYB flours. The effect of boiling, toasting, and soaking on the emulsion capacity of soybean and AYB flour samples were significant ($P<0.05$). Toasting for 10 minutes (TSF10min) reduced the emulsion capacity (EC) (27.50 %) of the soybean flour samples with further reduction when toasted for 15 minutes (TSF15min) (25.00 %). Soaking for 12 hours (SSF12h) caused a slight reduction in the EC (28.90 %) but a drastic increased with further soaking for 24 hours (SSF24h) (38.50 %). However, boiling had slight effect on the EC of soybean samples. Contrary to soybean flours results, toasting for longer time such as 10 minutes (TAYBF10min) increased the EC than toasting for 15 minutes (TAYBF15min). Similar observation was seen for boiling and soaking operation. Generally, processing increased the EC capacity of the AYB flour samples which suggested better emulsifying properties and would be desirable for salad dressing, sausage, cake and frozen desserts [5] since EC is used to study the emulsifying properties of proteins in food emulsion system. EC measures the highest amount of oil that needs to be added to cause phase separation [26]. The gelatinization temperature (GT) increased after 10 minutes of toasting (TSF10min) (86.67°C) and reduces after 15 minutes of toasting (TSF15min) (83.00°C), while soaking and boiling operations had lower GT compared to the RSF (raw samples), in soybean flour samples. Sample D and G showed no significant difference ($P>0.05$) while other samples showed significant difference ($P<0.05$). While, in AYB flour samples, the raw sample (RAYBF) had higher gelatinization temperature compared to the processed samples, especially toasting, which

  

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suggested that the processed samples would have a lower temperature at which the starch is converted into a water-soluble gel. Wettability is the time required for a given amount of flour to be wetted. The ability of food flours or powder to disperse is largely dependent on their wettability capacity. However, the polarity of the flour particles and the surface tension of liquid plays a major role in the wettability of flours [26]. Wettability of soybean flour decreased with processing such that RSF had the highest wettability values (14.82 s) and lowest in BSF30min (7.39 s). The results suggested that processed soybean flours would have lower dispensability. In AYB flour samples, wettability was highest in SAYBF12h (11.83 s) and lowest in BAYBF20min (7.22 s). Toasted AYBF had lower wettability compared to other samples which suggested that toasting affect the wettability of AYBF compared to other processing methods.

## CONCLUSION

This study revealed that processing had significant effects on the dietary fibre composition, proximate composition, and the functional properties of soybean and African yam bean flour samples. Comparing all samples to control, Toasting was found to increase significantly ($P<0.05$) IDF and TDF of soybean and African yam bean flour samples.

  

**Table VI: Functional properties of processed soybean flour samples.**

| Sample codes | Oil absorption capacity (g/ml) | Water absorption capacity (g/ml) | Foam capacity (ml) | Bulk density (g/ml) | Emulsion capacity (%) | Gelatinization temperature (°C) | Wettability (sec) |
|---|---|---|---|---|---|---|---|
| RSF | $2.12^{e} \pm 0.02$ | $4.50^{a} \pm 0.20$ | $19.03^{b} \pm 0.03$ | $0.51^{ab} \pm 0.00$ | $30.50^{b} \pm 0.02$ | $82.00^{c} \pm 0.20$ | $14.82^{a} \pm 0.02$ |
| TSF10min | $2.21^{d} \pm 0.02$ | $3.10^{c} \pm 0.02$ | $13.57^{f} \pm 0.08$ | $0.52^{ab} \pm 0.00$ | $27.50^{f} \pm 0.02$ | $86.67^{a} \pm 0.76$ | $11.55^{b} \pm 0.02$ |
| TSF15min | $2.26^{e} \pm 0.02$ | $3.25^{b} \pm 0.20$ | $13.07^{g} \pm 0.06$ | $0.61^{a} \pm 0.21$ | $25.00^{g} \pm 0.20$ | $83.00^{b} \pm 0.20$ | $9.57^{d} \pm 0.02$ |
| SSF12h | $1.80^{g} \pm 0.02$ | $3.28^{b} \pm 0.25$ | $17.86^{e} \pm 0.03$ | $0.49^{ab} \pm 0.00$ | $28.90^{d} \pm 0.02$ | $77.00^{d} \pm 0.20$ | $7..65^{f} \pm 0.02$ |
| SSF24h | $2.07^{f} \pm 0.02$ | $3.15^{bc} \pm 0.20$ | $18.03^{d} \pm 0.03$ | $0.52^{ab} \pm 0.00$ | $38.50^{a} \pm 0.02$ | $73.00^{f} \pm 0.20$ | $10.24^{c} \pm 0.02$ |
| BSF20min | $2.49^{a} \pm 0.02$ | $2.94^{d} \pm 0.20$ | $19.74^{a} \pm 0.02$ | $0.54^{ab} \pm 0.00$ | $29.30^{c} \pm 0.02$ | $75.00^{e} \pm 0.20$ | $8.45^{e} \pm 0.02$ |
| BSF30min | $2.32^{b} \pm 0.02$ | $3.16^{bc} \pm 0.20$ | $18.66^{c} \pm 0.03$ | $0.43^{b} \pm 0.00$ | $28.00^{e} \pm 0.20$ | $77.00^{d} \pm 0.20$ | $7.39^{g} \pm 0.02$ |
| LSD (0.05%) | 0.05 | 0.01 | 0.16 | 0.01 | 0.40 | 1.00 | 0.26 |

Mean values down the columns with different letters are significantly different ($P < 0.05$).

**Table VII: Functional properties of processed African yam bean flour samples.**

| Sample codes | Oil absorption capacity (g/ml) | Water absorption capacity (g/ml) | Foam capacity (ml) | Bulk density (g/ml) | Emulsion capacity (%) | Gelatinization temperature (°C) | Wettability (s) |
|---|---|---|---|---|---|---|---|
| RAYBF | $1.68^{e} \pm 0.02$ | $2.10^{g} \pm 0.02$ | $17.06^{a} \pm 0.02$ | $0.67^{d} \pm 0.00$ | $35.07^{c} \pm 0.02$ | $82.00^{a} \pm 0.20$ | $10.37^{d} \pm 0.02$ |
| TAYBF10min | $2.05^{b} \pm 0.02$ | $2.46^{e} \pm 0.02$ | $16.62^{a} \pm 0.02$ | $0.63^{f} \pm 0.00$ | $37.40^{a} \pm 0.02$ | $75.00^{d} \pm 0.20$ | $9.79^{e} \pm 0.02$ |
| TAYBF15min | $2.00^{c} \pm 0.02$ | $2.42^{f} \pm 0.02$ | $16.08^{a} \pm 0.11$ | $0.66^{e} \pm 0.00$ | $35.30^{b} \pm 0.02$ | $75.00^{d} \pm 0.20$ | $9.34^{f} \pm 0.02$ |
| SAYBF12h | $1.68^{e} \pm 0.02$ | $2.54^{d} \pm 0.02$ | $18.18^{a} \pm 0.02$ | $0.86^{a} \pm 0.00$ | $34.00^{d} \pm 0.20$ | $81.73^{a} \pm 0.64$ | $11.83^{a} \pm 0.02$ |
| SAYBF24h | $1.72^{d} \pm 0.02$ | $3.02^{c} \pm 0.02$ | $18.98^{a} \pm 0.02$ | $0.71^{c} \pm 0.00$ | $33.30^{e} \pm 0.02$ | $78.00^{c} \pm 0.20$ | $10.91^{b} \pm 0.02$ |
| BAYBF20min | $2.14^{a} \pm 0.02$ | $3.23^{b} \pm 0.02$ | $17.00^{a} \pm 5.21$ | $0.61^{g} \pm 0.00$ | $37.50^{a} \pm 0.02$ | $80.00^{b} \pm 0.20$ | $7.22^{g} \pm 0.02$ |
| BAYBF30min | $1.98^{c} \pm 0.02$ | $3.44^{a} \pm 0.02$ | $19.63^{a} \pm 0.23$ | $0.72^{b} \pm 0.00$ | $26.70^{f} \pm 0.02$ | $80.00^{b} \pm 0.20$ | $10.53^{c} \pm 0.02$ |
| LSD (0.05%) | 0.04 | 0.04 | 0.38 | 0.01 | 0.23 | 0.27 | 0.45 |

Mean values down the columns with different letters are significantly different ($P < 0.05$).

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