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Evaluation of proximate composition, functional properties and Antinutritional factors of aerial yam-soybean flour

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Abstract
Aerial yam (*Dioscorea bulbefera*) and soybean (*Glycine max*) were processed into flours. The flours were then blended at different ratios of (Aerial yam flour: soybean flour) 25.00:75.00; 37.50:62.50; 50.00:50.00; 62.50:37.50; and 75.00:25.00 respectively. Proximate composition, functional properties and Antinutritional factors of the blended flour samples were evaluated. The results obtained showed that aerial yam flour: soybean flour (25.00%:75.00%) had the highest protein, lipid, ash, fibre, and caloric value of 29.52 ± 0.202%, 11.30±0.025%, 4.03±0.015%, 2.76±0.069% and 429.34±2.065kcal respectively, and the lowest moisture and carbohydrate contents of 0.28±0.002% and 52.39±0.258%. The functional properties ranged between 0.5195±0.006 to 0.5882±0.006gcm^{-3} for bulk density, 1.9±0.001 to 2.2± 0.001 g/g for water absorption, 2.94±0.003 to 3.68±0.003g/g for oil absorption, 59.49±0.005 to 62.82±0.004% for emulsion capacity and 3.07±0.116 to 5.43±0.058% for foaming capacity. The Antinutritional factors ranged between 1.09±0.001 to 2.62±0.003mg/100g for hydrogen cyanide, 68.05±0.508 to 98.27±0.508mg/100g for phytate, 4.65±0.002 to 13.54±0.002 mg/100g for tannin and 5.31±0.012 to 11.23±0.025% for alkaloid. Some of the Antinutritional factors were found to be below the lethal dose range for human. Aerial yam flour-soybean flour blend at the right proportion could be useful in the confectionery food system and the pasta industry.

Keywords: Aerial yam flour, soybean flour, proximate composition, functional properties, Antinutritional factors

1. Introduction

Aerial yam (*Dioscorea bulbifera*) is a perennial, semi-wild food crop that grows on vines climbing unto poles and trees. It belongs to the yam family, *Dioecoreaceae*. This bulbils-bearing yam belongs to the order, *Dioscoreal*, family *Dioscoreaceae*, and genus *Dioscorea*. It is unpopular specie among the edible yam species. It is cultivated in the South East Asia, West Africa, and South and Central America. The wild form also occurs in both Asia and Africa (Nwosu, 2013) [17].

Aerial tubers or bulbils are harvested by manual plucking from the vine. It is included in the roots and tubers which are widely distributed throughout the tropics with only a few in the temperate regions of the world (Coursey, 1967, FAO, 1999) [6, 8]. Together with cereals, they constitute the main source of energy in the tropics. This specie of yam is consumed by a small number of communities and is generally under-utilized both at subsistence and commercial levels for a number of reasons (Igyor *et al*, 2004) [11]. These include, it having a relatively bitter taste compared to other yam species, is unknown to most people, and much work has not been done on it to suggest uses to which it can be put to. However, there is a lot of potential for aerial yam in terms of its nutritional and functional properties that could be taken advantage of to produce diverse industrial products, not to mention its socio-economic importance (Sanful and Engmann, 2016). *Dioscorea bulbifera* has been widely used in the Chinese medical system as a valuable herb in the process of rebuilding and maintaining kidney function (Ahmed *et al*, 2009) [1]. This herb was also found to have a beneficial effect in treating diseases of the lungs and Spleen, and many types of diarrhea, improving digestion and metabolism (Coursey, 1967) [6].

In Asia, this herb has been highly recommended for treating diabetes disorder. It has been traditionally used to lower glycemic index, providing a more sustained form of energy and better protection against obesity and diabetes, however, this property has not yet been scientifically proven (Brand–Miller *et al*, 2003) [5].

Aerial yam, being a lesser known food crop, has not been processed to any significant extent commercially. It is only a small portion of the crop that is processed into instant yam flour which is particularly popular in Yoruba speaking areas of West Africa, but less so in other parts of the continent (Orkwor *et al*, 1998) [22].

Processing aerial yam to flour can help to reduce the over dependent on wheat flour for our baked products and post-harvest losses (Princewill and Ezembaukwu, 2015) [24].

Soybean (*Glycin max*), an important oil seed belonging to the family, *Leguminosae*, is usually grown as a food crop. Soybean production and utilization as food arose in ancient China not later than the 11th century. It then became grown in other parts of the world just in the 20th century. The major producing countries are the United States, Brazil, China and Argentina (Iwe, 2003).

Soybean is mainly cultivated for its seeds, used commercially as human food and livestock feed, and for the extraction of oil. Soy foods are becoming some of the fastest growing categories in the food industry, with products ranging from traditional soy foods to protein ingredients and from daily and meat alternatives to various types of western and traditional foods enriched with soybean flour and or its fractions (Iwe, 2003).

Soybean has a unique chemical composition on an average dry-matter basis; it contains about 40% protein and 20% oil. With this composition, it ranks highest in terms of protein content among all the legumes (Iwe, 2003).

Industrially, soy protein products had been used as late as the 1960s as nutritional and functional food ingredients in some food categories available to the consumer. The earliest known of such products in Nigeria is the soy-ogi developed at the Federal Institute of Industrial Research FIIRO), Oshodi. Substituting wheat flour with soybean up to 25% will go a long way to increase noodles variety, make them affordable to many and boost their nutritional content (Omeire *et al*., 2014) [19].

Supplementation of sweet potatoes with crops like soybeans, promote institutional utility, especially if properly processed (Iwe, 1997). This study was therefore, undertaken to determine the proximate composition, antinutritional factors and functional properties of aerial yam soybean flour blends at different proportions.

2. Materials and Methods

2.1 Sources of raw materials

The aerial yam was obtained from the National Root Crops Research Institute (NRCRI) Umudike, Abia State, while the soybean seeds were purchased from the urban market in Uyo, Akwa Ibom State, all in Nigeria.

2.2 Preparation of aerial yam flour

This was done according to the method as describe by Princewill – Ogbonna and Ibeji (2015) [24]. Accordingly, the bulbs were manually peeled, washed and cut into chips, after which they were put into an oven and dried at 70^0C for 12 hours. The dried chips were then milled into powder (flour) using attrition mill, and then stored in an airtight packaging material for subsequent use.

2.3 Preparation of soybean flour

This was done according to the method of Iwe (2003). The seeds were screened to remove foreign materials, splits and damaged beans. This was followed by washing, and then boiled in water at 100^0C for 30 minutes. It was drained and dehulled manually, and then oven dried at 70^0C for 12 hours. This was followed by milling in an attrition mill, and the finely ground (milled) full fat dehulled soybeans was Sieved. The flour was then packaged in a polyethylene bag for subsequent use.

2.4 Preparation of sample blends

The aerial yam- soybean flour blends were prepared at the ratios (aerial yam flour: soybean flour in %) 25.00:75.00; 37.50:62.50; 50.00:50.00; 62.50:37.50 and 75.00:25.00 respectively.

2.5 Determination of proximate composition

Proximate analysis was carried out according to the Official Methods of Analysis (AOAC, 1990) [2].

2.6 Determination of antinutritional factors

The Hydrocyanide (HCN) was determined by the methods of Egan and Bradbury, (1998) [7]. The Oxalate was determined according to the method described by Oke, (1969) [18]. The phytate was determined by the method of Mecance and Widdowson, (1955) [16]. The Tanin content was determined according to the Folin-Dennis Spectrophotometric method described by Pearson (1976) [23]. Alkaloid was determined by the gravimetric method of Harbone (1973) [9].

2.7 Determination of functional properties

The bulk density, water absorption capacity (WAC) and oil absorption capacity (OAC) were determined according to the method described by Onwuka (2005) [21]. The foaming capacity was determined according to the method of Lawhon *et al*, (1972) [14]. The Emulsion capacity was determined by the method of Beuchat *et al* (1975) [3].

2.8 Statistical analysis

Data obtained were recorded in triplicate and subjected to statistical analysis of variance (ANOVA) with the mean separated by Duncan's multiple range tests at 5% level of significance.

3. Results

The results of the proximate composition, functional properties and antinutritional factors of aerial yam-soybean flours blends are shown in the tables below:

Table 1: Results of the proximate composition of aerial yam-soybeans flour blend samples

Sample	Moisture %	Ash %	Fibre %	Protein %	Lipid %	CHO %	Caloric Value (kcal)
A	0.28±0.002^{c}	4.03±0.015^{e}	2.76±0.006^{b}	29.52±0.202^{d}	11.30±0.025^{b}	52.39±0.258^{e}	429.34±2.065^{e}
B	0.36±0.001^{c}	3.16±0.021^{c}	2.13±0.015^{d}	26.17±0.085^{e}	8.93±0.039^{a}	59.61±0.151^{b}	423.49±1.214^{b}
C	0.86±0.001^{b}	2.61±0.025^{a}	1.76±0.012^{c}	22.81±0.056^{c}	8.85±0.020^{a}	63.97±0.105^{a}	426.77±0.824^{d}
D	0.86±0.001^{b}	1.67±0.025^{a}	1.14±0.015^{a}	21.18±0.175^{b}	7.89±0.023^{e}	68.12±0.238^{c}	428.21±1.589^{c}
E	1.09±0.001^{a}	1.15±0.031^{d}	1.00±0.020^{a}	16.98±0.175^{a}	6.07±0.040^{c}	74.80±0.266^{d}	421.75±1.964^{a}

Values are means ± standard deviation of triplicate determinations.

The main values in the same column having similar superscripts are not significantly different ($p<0.05$) from each other.

Sample 'A'=25.00% aerial yam flour: 75.00% soybean flour
Sample 'B'=37.50% aerial yam flour: 62.50% soybean flour
Sample 'C'=50.00% aerial yam flour: 50.00% soybean flour
Sample 'D'=62.50% aerial yam flour: 37.50% soybean flour
Sample 'E'=75.00% aerial yam flour: 25.00% soybean flour

Table 2: Results of functional properties of aerial yam – soybeans flour blend samples

Sample	Bulk Density (g/cm^{-3})	Water Absorption Capacity (g/g)	Oil Absorption Capacity (g/g)	Emulsion Capacity (%)	Foaming Capacity (%)
A	0.5882± 0.006^{b}	1.9 ±0.001^{a}	3.68 ±0.003^{c}	59.49± 0.005^{d}	3.07± 0.116^{b}
B	0.5556± 0.004^{c}	1.9±0.001^{a}	3.50±0.001^{a}	61.54±0.006^{c}	3.27±0.058^{d}
C	0.5263±0.005^{a}	2.2±0.001^{b}	3.04±0.002^{b}	60.00±0.007^{e}	3.80±0.100^{c}
D	0.5404±0.005^{e}	2.0±0.002^{c}	3.31±0.002^{e}	62.82±0.004^{b}	5.13±0.115^{a}
E	0.5195±0.006^{a}	2.1±0.001^{c}	2.94±0.003^{d}	60.76±0.005^{a}	5.43±0.058^{e}

Values are mean ± standard deviation of triplicate determinations. The mean values in the same column having similar superscripts are not significantly different ($p<0.05$) from each other.

Sample 'A'=25.00% aerial yam flour: 75.00% soybean flour
Sample 'B'=37.50% aerial yam flour: 62.50% soybean flour
Sample 'C'=50.00% aerial yam flour: 50.00% soybean flour
Sample 'D'=62.50% aerial yam flour: 37.50% soybean flour
Sample 'E'=75.00% aerial yam flour: 25.00% soybean flour

Table 3: Results of anti- nutritional factors in aerial yam-soybean flour blend samples

Sample	HCN (mg/100g)	Oxalate (mg/100g)	Phytate (mg/100g)	Tannin (mg/100g)	Alkaloid (%)
A	1.14±0.002[c]	68.05±0.508[d]	24.06±0.005[e]	8.47±0.003[e]	8.10±0.015[d]
B	1.56±0.003[b]	71.28±0.830[e]	15.14±0.004[d]	4.65±0.002[c]	7.63±0.023[b]
C	1.09±0.001[c]	84.19±1.016[a]	5.00±0.007[c]	13.54±0.002[d]	11.23±0.035[a]
D	2.60±0.002[a]	94.16±0.880[c]	13.10±0.008[a]	5.63±0.001[b]	5.31±0.012[e]
E	2.62±0.003[a]	98.27±0.508[d]	11.25±0.011[b]	5.52±0.004[a]	6.65±0.03[c]

Values are means ± standard deviation of triplicate determinations. The mean values in the same column having similar superscripts are not significantly different ($p<0.05$).

Sample 'A'=25.00% aerial yam flour: 75.00% soybean flour
Sample 'B'=37.50% aerial yam flour: 62.50% soybean flour
Sample 'C'=50.00% aerial yam flour: 50% soybean flour
Sample 'D'=62.50% aerial yam flour: 37.50% soybean flour
Sample 'E'=75.00% aerial yam flour: 25.00% soybean flour

4. Discussion

The results of the proximate composition of aerial yam flour-soybean flour blends are presented in Table 1.

There was no significant difference ($p<0.05$) in moisture contents of samples A, B and C while there was significant difference between sample D and E. The moisture contents of the samples ranged between 0.28 ± 0.002 to 1.09 ± 0.001%, with sample A having the least, 0.28 ± 0.002%, and sample E having the highest, 1.09 ± 0.001% moisture content. Samples B, C and D had 0.36 ± 0.001%, 0.41 ± 0.002% and 0.86 ± 0.001% moisture contents respectively.

Moisture content of samples is presumed as one of the most important determination of shelf stability (Omohimi *et al*., 2014) [20]. The moisture content values for the flour samples ensure adequate storage in packages.

The ash content of the flour samples showed significant difference ($p<0.05$) among the samples. Sample A had the highest ash content of 4.03 ± 0.015 %, while sample E had the least, 1.15 ± 0.031%. This is an indication that aerial yam flour-soybean flour blend is a potential good source of minerals required by the body. The range of values is higher than that earlier reported for false yam flour, 1.89 to 2.26% by Umoh and Iwe (2014) [27].

There was no significant difference ($p<0.05$) between sample D and sample E, in terms of percentage fibre compositions. However, there was significant difference ($p<0.05$) amongst samples A, B, C and D.

Sample A had the highest fibre content, 2.76 ± 0.06%, while sample E had the lowest value of 1.00 ± 0.020%. Samples B, C and D had 2.13 ± 0.015%, 1.76 ± 0.012%, and 1.14 ± 0.015% respectively. This range of value is higher than that of false yam flour (0.29 to 1.51%) as reported by Umoh and Iwe (2014) [27]. Though crude fibre does not contribute nutrients or energy, aerial yam flour/soybean flour blends is a good source of dietary fibre which is essential for food bowel movement and helps in preventing obesity, diabetes, cancer of the colon and other ailments of the gastro-intestinal tract of man.

There was a significant difference ($p<0.05$) in protein contents of the flour blend samples. Sample A had the highest value, 29.52 ± 0.202% while sample E had the lowest, 16.98±0.175%. The highest percentage composition of soybean flour in sample A (75.00%) as against 25.00% aerial yam flour may be due to the high protein content of soybean compared to aerial yam. The range of protein compositions in the flour samples is higher than that of false yam flour (3.01 to 6.03%) as reported by Umoh and Iwe (2014) [27].

Lipids contents in the flour samples showed significant difference ($p<0.05$) in terms of percentage composition. Sample A had, 11.30 ± 0.025% being the highest, while sample E had the lowest, 6.07 ± 0.040%. The highest lipid content of sample A may be attributed to the fat content the soybean flour incorporated into the sample.

The carbohydrate content of the flour blend samples were significantly different ($p<0.05$) from each other. The carbohydrate content ranged 52.39 ± 0.258 to 74.80 ± 0.266%, with sample E having the highest (74.80 ± 0.266%), while sample A had the lowest value of (52.39 ± 0.258%). The carbohydrate content decreased with increase in the percentage of soybean flour added. This is in agreement with the report of Omeire *et al* (2014) [19]. The decrease could be due to the low carbohydrate content of soybean flour (Iwe, 2004) [12].

The caloric (energy) values observed were significantly different ($p<0.05$) from each other. Sample E had the least value, 421.75 ± 1.964kcal while sample A had the highest value, 429.34 ± 2.065kcal. The caloric values for the flour blend samples are higher than those of white flour for bread making, 341kcal (Holland *et al*, 1988); potato flour, 351.0kcal; wheat flour, 364.0kcal (Macrae *et al*, 1993b) [13] and false yam flour (Umoh and Iwe, 2014) [27]. The implication of the high energy value of aerial yam flour/soybean flour blends is that it is a potential source of energy, hence may be useful in formulating food products to supplement the daily energy requirement of man.

The results of functional properties of aerial yam – soybean flour blends are shown in Table 2. The values of the bulk density ranged between 0.5195 ± 0.006 and 0.5882 ± 0.006gcm^{-3}. Sample 'A' had the highest bulk density, and is significantly different ($p<0.05$) from the other samples. Sample 'E' had the least bulk density, 0.5195 ± 0.006gcm^{-3} and was not significantly different ($p<0.05$) from sample 'C'. This range of values is comparable with 0.58 to 0.70 g/ml for wheat: Acha: soybean flour blends, as reported by Omeire *et al* (2014) [19]. Iwe and Onadipe (2001) [13] reported that low bulk density is desirable in infant feeding, while flours with high bulk density are used as thickeners in food products.

The water absorption capacity ranged between 1.9±0.001

and 2.2 ± 0.001g/g. Sample A and B had the least value, 1.9 ± 0.001g/g, which was not significantly different ($p<0.05$) from one another. Sample C had the highest value, 2.2 ± 0.001g/g, and was significantly different ($p<0.05$) from other samples. The water absorption capacity was observed to be decreasing as the percentage of soybean flour in the blends increases. This is in agreement with the report of Omeire *et al* (2014) [19]. Water absorption capacity may ensure product cohesiveness (Housson and Ayenor, 2002).

Sample A recorded the highest oil absorption capacity 3.68±0.003g/g, while sample E had 2.94±0.003g/g. There was significant difference ($p<0.05$) in all samples. This range of values is comparable with that of aerial yam earlier reported by Princewill-Ogbonna and Ezembaukwu (2015) [24], which ranged from (2.2g/g) to (3.2g/g). The observed value is also comparable with (1.89 to 3.80%) for false yam flour, earlier reported by Umoh and Iwe (2014) [27].

The emulsion capacity ranged between 59.49±0.005 to 62.82±0.004%. There was significant difference ($p<0.05$) in all samples, with sample "D" having the highest value, 62.82±0.004% while sample 'A' had the least, 59.49±0.005%. Emulsifying capacity is important in its application in batters and dough. The high emulsion capacity values as observed in the flour blend samples is an indication of its potential useful ingredient in flour confectioneries.

There was significant difference ($p<0.05$) in foaming capacity among the sample. Sample E had the highest 5.43±0.058% while sample 'A' had the least, 3.07±0.116%. The observed values are within the range for false yam flour, as reported by Umoh and Iwe (2014) [27], 1.00% to 4.81%. Foaming capacity/stability is important in products such as cake and yam balls. Therefore, aerial yam-soybean flour blend could be useful in the confectionery food systems.

The results of the antinutritional factors in aerial yam-soybean flour blends, as presented in Table 3, showed that there was no significant difference ($p<0.05$) between sample "D" and sample "E" in terms of Hydrogen cyanide (HCN) contents. Meanwhile, there was significant difference ($p<0.05$) among other samples. The HCN content ranged between 1.09±0.001 to 2.62±0.03mg/100g, with sample 'C' having the least, 1.09±0.001mg/100g. This range of value is high, compared to 0.231 to 0.465mg/100g for false yam flour (Umoh. 2013) [26], but lower than 25.8mg/kg HCN for roasted garri (Bradbury and Holloway, 1988) [7]. The knowledge of cyanogenic glycosides content of food is vital because cyanide, being an effective cytochrome oxidase inhibitor interferes with aerobic respiratory system (Onwuka, 2005) [21].

The oxalate contents in the samples showed a significant difference ($p<0.05$), with sample A having the least, 68.05±0.508mg/100g, while sample "E" had the highest, 98.27±0.508mg/100g. The oxalate content was observed to increase with decrease in the percentage of soybean flour added. The high content of calcium oxalate crystals, about 780mg/100g in some species of cocoyam (*Colocasia Xanthosoma*) has been implicated in the acridity or irritation caused by cocoyam (Bradbury and Holloway, 1988) [7].

There was significant difference ($p<0.05$) in the phytate content among the samples. Sample A had the highest, 24.06±0.005mg/100g, while sample C had the least, 5.00±0.007mg/100g, as shown in Table 3.

Tannin values for the samples ranged between 4.65±0.002 to13.54±0.002mg/100g, showing a significant difference ($p<0.05$) among all samples. Sample B recorded the least tannin content, (4.65±0.002mg/100g), while sample C had the highest value, 13.54±0.002mg/100g. This value is low, compared to 21.241mg/100g for false yam flour (Umoh, 2013) [26]. Tannins have been found to inhibit the digestibility of protein.

Alkaloids content showed a significant difference ($p<0.05$) among samples. The values ranged between 5.31±0.012 to 11.23±0.025%. This range of values is higher than 1.365 to 3.12% for false yam flour (Umoh, 2013) [26]. Some of the toxicological manifestations of potato glycol alkaloids include gastro intestinal upset and neurological disorders, especially in doses in excess of 20mg/100g sample. Simple boiling removes the alkaloids present in most cultivated species of yam (Onwuka, 2005) [21].

5. Conclusion

The result of the study showed that sample A (25% aerial yam flour: 75.00% soybean flour) blend, had the highest protein, lipids, ash and fibre contents as well as caloric value. The least moisture content in sample A, compared to samples B, C, D and E ensures adequate storage in packages, while the low bulk density is desirable in infant feeding, among others. Therefore, sample A is most suitable in the formulation of food products, especially bakery/confectioneries as well as extruded foods (pasta) systems.

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7. References

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