

EFFECT OF GERMINATION ON PROXIMATE COMPOSITION, MINERAL BIOAVAILABILITY AND FUNCTIONAL PROPERTIES OF AFRICAN YAM BEAN SEED FLOUR

Abioye, V.F., Adegbola, G.M and Onidare, O.V

Department of Food Science and Engineering,
Faculty of Engineering and Technology, LAUTECH

ABSTRACT

The effects of germination on the quality attributes of African yam bean (*Sphenostylis stenocarpa*) seed, an underutilized legume were investigated. The seeds were subjected to germination at 25 °C for 24 h, 48 h, 72 h and 96 h after which they were dried, milled into flour and the effects of germination on the proximate composition, anti-nutritional contents, mineral bioavailability and the functional properties of the flour samples were determined. The protein contents of the germinated flour samples ranged between 20.3 and 21.3% with highest value recorded after 24 h of germination. The fat content, ash content and the crude fibre of the germinated flour samples ranged from 2.27- 2.67%, 3.47 -3.80 and 2.10 - 2.67%, respectively. The fat and the crude fibre decreased with the germinating period while the ash contents increased. There was a general increase in the mineral availability with increase in germination period. Calcium content increased from 48.33 to 51.67 mg/100 g; iron content from 6.23 to 6.43 mg/100 g; magnesium from 41.67 to 48.33 mg/100 g; and phosphorus from 141.67 to 146.67 mg/100 g. There were reductions in the anti-nutritional contents of the flour samples with the germinating process. There was about 50% reduction in oxalate content; 35% reduction in phytate and 100% in trypsin inhibitor content. The germination process had effects on the swelling capacity, foam capacity and water absorption capacity of the flour samples. The bulk density ranged between 0.67 and 0.71 g/cm³; water absorption capacity from 196.67% to 178.33%; swelling capacity from 1.77-1.50%; and foaming capacity 39.43-31.57%. Germination of African yam bean seed had effects on the proximate composition, functional properties, reduction of the anti-nutritional content and increment on the bioavailability of some minerals which could help to increase the potential of this underutilized crop in food products.

Keywords: African yam bean, germination, functional, mineral bioavailability, anti-nutritional

Introduction

African yam bean (*Sphenostylis stenocarpa*) is a climbing legume adapted to lowland tropical conditions. It is among the lesser known and under-exploited legumes which has attracted research interest in recent times (Uwaegbute, 2012). It is widely cultivated in Central African Republic, Zaire, and other East Africa countries for its tubers and edible seeds (Ameh, 2007). Nigeria is very significant for African yam bean production (Potter, 1992) where extensive cultivation has been reported in the South Eastern, Western and Southern parts of Nigeria (Abbey and Berezi, 1988; Saka *et al.*, 2004).

The protein content in African yam bean seeds has been reported to be between 21 and 29%. The protein content in the tubers is about 2 to 3 times the amount in potatoes and higher than those in yam and cassava (Okigbo 1973; Amoatey *et al.*, 2000; Uguru and Madukaife 2001). The amino acid values in AYB seeds are higher than those in pigeon pea, cowpea, and bambara groundnut

(Uguru and Madukaife, 2001). It is rich in minerals such as potassium, phosphorous, magnesium, calcium, iron and zinc but low in sodium and copper (Edem *et al.*, 1990). The seeds contain tannins, trypsin inhibitors, hydrogen cyanide, saponins and phytic acid (Akinmutimi *et al.*, 2006).

The legumes are a good source of dietary protein. They are cheaper than animal products such as meat, fish, poultry and egg. They are consumed worldwide as a major source of cheap protein and especially in the developing or poor countries where consumption of animal protein may be limited as a result of cultural or religious factor, economic and social factors (). In spite of its composition, AYB has a low consumption rate due to its long cooking time compared with that of cowpea, possession of beany flavour and its constituents of anti-nutritional factors (Nwokolo, 1996; Otah, 1999; Ebiokpor and Lloyd, 2005).

The quality of foodstuffs may be improved by through various processes such as boiling, autoclaving and sprouting/germination and

studies have also shown that germination improves the nutritive value of cereals and legumes (Onwuka *et al.*, 2009; Mohammed *et al.*, 2011). It has also been demonstrated that germination modifies the functional, nutritional and antioxidant activities of proteins (Amza *et al.*, 2013). The process of germination has been developed in some countries as an alternative to defeat some of the disorders such as undesirable tastes and smell, as well as the presence of anti-nutritional factors associated with untreated grains (Sangonis and Machado, 2007).

This study was therefore aimed at determining the effect of germination on proximate mineral composition, antinutritional, and functional properties of African yam bean seed. This would enhance the utilization of this underutilized legume in developing countries like Nigeria and hence improve the nutritional status of the populace.

Materials

AYB used for this research work were obtained from the Genetic Resources Centre, Institute of Agriculture and Research Training, Ibadan, Nigeria (IAR&T), while all the chemicals used were of analytical grade.

Methods

African yam bean seeds were sorted to remove unwanted materials, cleaned and weighed. One hundred grams (100 g) of the cleaned bean seeds were surface sterilized for 30 min in a 1% sodium hypochlorite solution. The bean seeds were rinsed five times with distilled water (1:3 w/v) and soaked for 9 h in a glass beaker in tap water (1:3 w/v). The presoaked seeds were allowed to sprout on sterile germinating trays lined with filter paper which was kept moist by layers of damp cotton wool. Germination was carried out at 25 °C and samples collected at 0 h (control), 24 h, 48 h, 72 h and 96 h. The germinated seeds were dried, milled into flour and packaged in cellophane bags for further analyses.

Analysis

Determination of Chemical Composition

The flour samples were analyzed for moisture, ash, crude fibre, protein (N*6.25) and crude fat while the carbohydrate was determined by difference according to the method described by AOAC (2005). Selected minerals (calcium, iron, magnesium, aluminum, phosphorous) of the seed were determined using the dry-ash techniques (AOAC 2005). 1g of each sample were dry-ashed at 450 °C until completely ashed. The minerals were extracted using 10% (v/v) HCl, filtered and made up to 100ml in a volumetric flask.

Determination of anti nutritional factors

The anti nutritional factors determined on the samples included the phytate, trypsin inhibitor and oxalate. Phytate was determined by the anion exchange method which is the modified Holts Method using HN4CNS as standard. The oxalate content of the samples was determined using titration method. Trypsin inhibitor was determined using the spectrophotometric method, described by Arntfield *et al.* (1985).

Determination of Functional Properties

The bulk density of the flour samples were determined by the method of Akpapunam and Markakis (1981). The bulk density (g/ cm³) was calculated as weight of flour (g) divided by flour volume (cm³). The swelling capacity of the flour samples was determined according to Abbey and Ibeh (1988) and It was calculated as the ratio of the volume occupied after swelling. The foaming capacity of flour samples was determined according to Onwuka (2005) while Water absorption capacity (WAC) was determined using the method of Mbofung *et al.* (2006).

Results and Discussion

The proximate composition of African yam bean seeds subjected to different germination periods (Table 1). Indicates the moisture contents to be ranged between 8.67 and 9.13% with sample germinated for 96 h having the highest value while the sample germinated for 0 h had the least value. This is in line with a previous report that the moisture content after 24 h at 37°C increased from 30 to 40 % and the increase was approximately 75-85% after 48 h of germination (Chaudhary and Vyas, 2014). Based on this, it is evident that during germination there is a marked increase in moisture content which may be contributed to the fact that during germination the whole grains absorb moisture from the soaking medium for metabolism to initiate and this in turn influence the structure of the grain. This could mean that the longer the germination period the more the penetration of water into the seed.

The protein content ranged between 20.30 and 21.70% with sample germinated for 24 h having the highest value while the sample germinated for 96 h had the least value. This increase after 24 h could be attributed to a net synthesis of enzyme protein (e.g. protease) by germinating the seed. The result corresponded with earlier reports of increase in protein content during germination of various cereals, legumes and other seeds (Yagoub *et al.*, 2008; Uchehgbu, and Amulu, 2015). However there was decrease in the protein content with increase in germinating time. Several researches have also reported significant reduction in protein content post germination with

consequent increment in amino acid observed because of enhancement in the protease activity during germination (Chaudhary and Vyas, 2014). The fat content ranged between 2.27 and 2.67%, with the sample germinated for 0 h having the highest value while the sample that was germinated for 96 h had the least value. The observed decrease in the fat contents of the germinated seeds might be due to the increased activities of the lipolytic enzyme during germination. These enzymes hydrolyze fats to simpler products which can be used as a source of energy for developing embryo. This decrease in fat content may be an advantage in storage due to the fact that high fat foods are susceptible to spoilage. The carbohydrate contents ranges between 60.57 and 62.40% with sample germinated for 96 h having the highest value while the sample at 0 had the least value.

There was a gradual increase in the mineral content with increase in the hours of germination and it was significantly ($p < 0.05$) different. This means that there was synthesis of these minerals and some that were in combined form with some of the anti nutritional components were made available by the germination process. The crude fiber contents ranged between 2.10 and 2.67 with sample germinated for 0 h having the highest value while sample germinated for 96 h had the least value.

The mineral composition of African yam bean seeds subjected to different germination period (Table 2) shows that the calcium content ranged between 48.33 and 53.33 mg/100 g with the sample germinated for 48 h and 72 h having the highest value while sample germinated for 0 h had the least value. The phosphate content ranged between 141.67 and 146.67 mg/100 g; with the sample germinated for 48 h and 96 h having the highest value while the sample germinated for 0 h has the least value. The iron content ranged between 6.20 and 6.43 with sample germinated for 96 h having the highest value while the sample germinated for 24 h having the least value. The legumes are generally low in iron contents but the amount found in African yam bean is relatively high and this is beneficial to blood formation in the body. The magnesium content ranged from 41.67 to 48.33 and this increased with the germination period while the highest value was obtained after 72 h of germination. The aluminum contents ranged from between 0.20 and 0.23 and the values are not significantly ($p < 0.05$) different from each other. This could mean that the germination process led to availability of more minerals in the seed.

The result of the anti-nutritional composition of AYB subjected to different soaking and germination periods (Table 3) shows that the oxalate content ranged between 6.67 and 13.33 mg/100 g. There was gradual decrease with

germination process, with the samples germinated for 0 h having the highest value while sample germinated for 96 h had the least value but was relatively low when compared with earlier reports of (Umoren *et al.*, 2005). The amount of oxalate ingested may be an important risk factor in the development of idiopathic calcium oxalate nephrolithiasis (Homes and Kennedy, 2000) which could be eliminated by soaking and germination process. Oxalate has been reported to have a significant effect on the mineral level, by forming complexes with minerals and hence makes them unavailable for the body use (Adegunwa *et al.*, 2012). The phytate content values ranged between 21.67 and 33.33 mg/100 g, there was a gradual decrease with the germination process and the sample germinated for 96 h had the least value. The decreases in phytic acid in germinated samples were comparable to the results reported for other germinated legumes such as African oil bean (Enugiugha *et al.*, 2003). The trypsin content ranged from 0.13 to 0.33 mg/100 g with sample germinated for 0 h having the highest value while there were no traces of trypsin after 96 h of germination. This suggests that increasing the germination time may ensure a reasonable reduction or elimination of trypsin inhibitor in African yam bean seed.

The packed bulk density content ranged from 0.72 to 0.74 g/cm³ and the loose bulk density content ranged between 0.41 and 0.42 g/cm³ (Table 4). The bulk density is generally affected by the particle size and the density of the flour and it is very important in determining the packaging requirement, material handling and application in wet processing in the food industry. Indicating that the germination of African yam bean seed does not have effects on the packaging requirement of the flour samples (Adebowale *et al.*, 2008). The swelling capacity decreased with increase in germination period, indicating that germination may give flours with lower swelling capacity. The foaming capacity ranged between 31.57 and 39.43%. The foaming capacity decreased with increase in the germination period. Foamability is related to the rate of decrease of the surface tension of the air/water interface caused by absorption of protein molecules (Sathe *et al.*, 1982). Indicating that the effect of germination process on the protein content of AYB had influence on the foaming capacity of the flour samples. Water absorption content ranged between 178 to 196.67%. Water absorption capacity increased with increase in the germination period. Water absorption is the amount of water absorbed by the flour to produce dough of workable consistency. It is determined by the protein content of the flour, the amount of starch damaged during milling and the presence of non-starch carbohydrates. Water Absorption Capacity

Table 4 Functional composition of germinated African yam bean seed flour

Sampl e	LBD (g/cm ³)	PBD (g/cm ³)	SC (%)	FC (%)	WAC (%)
A	0.42a	0.74a	1.77a	39.43a	196.67a
B	0.42a	0.73a	1.63b	38.33b	195.00a
C	0.42a	0.73a	1.57bc	36.03c	185.00b
D	0.42a	0.72b	1.53bc	34.60d	183.33bc
E	0.41a	0.72b	1.50c	31.57e	178.33c

Mean values with the same alphabets within the same column are not significantly ($p < 0.05$) different from each other

Keys;

LED-Loose Bulk Density

PBD-Packed Bulk Density

SC- Swelling Capacity

FC- Foaming Capacity

WA-Water Absorption

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