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Original Research Paper

Proximate composition and some functional properties of flour from the kernel of African star apple (*Chrysophyllual albidum*)

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***Akubor[1] Peter Isah , Yusuf[2] Danladi and Obiegunam[3] James Ejike**

[1] Department of Food Science and Technology, University of Nigeria, Nsukka,Nigeria.
[2] Department of Science Laboratory Technology, Federal Polytechnic, Idah,Nigeria.
[3] Department of Food Science and Technology, Nnamdi Azikiwe University , Awka,Nigeria.

*Corresponding Author
Email : akuborpeter@gmail.com

The objective of this work was to assess the proximate composition and selected functional properties of flour from African star apple. Ripe fresh African star apples were washed and the pulp removed manually. The seeds were cracked manually and the kernels were separated from the hulls. The kernels were cut into thin slices of 1 cm thickness and hot-water blanched at 90°C for 5min. The slices were sun dried at 30±2°C to constant weight, milled and then sieved. The pulp, fresh kernel and flour were analyzed for their proximate composition. The flour functional properties were determined and compared with those of wheat flour. The results showed that the pulp contained 35% moisture which was higher than 20% for the fresh kernel. The moisture content decreased from 20% in the kernel to 9% in the flour. The ash contents of the pulp, kernel and flour were 4, 2.5 and 3.8%, respectively. The protein content of the flour was 4.5%, a value which was higher than the 20% for the pulp and 3.5% for the kernel. Crude fat was concentrated more in the kernel than in the pulp. The fat content increased to 9.3% in the flour from 8.4% in the pulp. The crude fiber content decreased from 5% in the pulp to 2.8% in the flour. The flour (70.6%) contained higher amount of carbohydrate than the kernel (63.6%) and pulp (52%). The water absorption capacity (250%) and oil absorption capacity (167%) of the African star apple kernel flour (ASAKF) were higher than those of wheat flour (WF) which were 130 and 135%, respectively. However, the emulsion and foaming properties of (ASAKF) were lower than those of WF. The least gelation concentration of ASAKF and WF were 10 and 8% (w/v), respectively.

Key words: African star apple, kernel, flour, proximate composition, functional properties

INTRODUCTION

As human population continued to grow, there is a considerable world wide interest in the utilization of lesser known plants as potential sources of human and animal feeds. Analysis of several by-products of plant foods such as mango seeds (Dhingre and Kapoor, 1985), neem seed cake (Udeyasekhara, 1987), tomato seeds (Rao, 1991), orange seeds (Akpata and Akubor, 1999) e.t.c have been carried out. The seed of African star apple has not been evaluated in this regard. African star apple is a tropical plant which belongs to the family *supotaceae*. It is a forest plant but is usually planted as a compound tree in villages. The plant produces edible fruit. The consumption of this fruit is very common in the entire gulf of Guinea and other African countries such as Cameroon, Congo and Nigeria (Ejiofor and Okafor,, 1997). In Nigeria, the fruit is gathered for household use or for sale in local markets during the months of December to April. The fruit is relished for its testy fleshy pulp. The pulp is consumed in its natural form by pressing hard and sucking the pulp. The taste is mildly acidic. The fruit is known by various tribal names in Nigeria as *agbalumo* (Yoruba), *udara* (Ibo) and *ehya* (Igala). The properties of the pulp have been extensively studied.

The pulp is reported as an excellent source of vitamins, iron, flavour to diets and raw materials to some manufacturing industries (Adisa *et al*, 2000, Amusa *et al*, 2003). However, Amusa *et al*., (2003) reported that the pulp goes bad after 5 days. Such post harvest losses have been minimized through processing of the fruit into value added products such as juice and jam (Chukwumalume *et al*., 2010). In contrast, little research on the kernel exists in the literature. However, Chukwumalume *et al*., (2010)showed that the seed is a good source of vegetable oil. The processing applications of the oil have been suggested (Idowu *et al*, 2006). Other studies on the seed bordered on the antimicrobial properties (Idowu *et al*, 2006) and the potential use of the seed as food ingredient. The seeds could be processed into flour and used in similar manner other flours such as orange seed (Akpata and Akubor, 1999) and mango kernel (Arogba, 1997, 2002) are used. This will, however, depend on the knowledge of its chemical composition and functional properties. Quality attributes of developed food products are generally affected by the functional properties of the flour (Kinsella, 1987). Even though the methods used in the measurement of these functional properties are open to various criticisms on the basis of rigor (Kinsella, 1987), and trial and eror (Gordon, 1993), they provide a guide for the use of flours in different food formulations. Information on the chemical composition and functional properties of star apple kernel is lacking in the literature. Thus, the objective of this study was to determine the proximate composition and functional properties of flour prepared from African star apple and to compare them with those of wheat flour.

MATERIALS AND METHODS

Ripe and fresh African star apples (*Chrysophyllum albidium*) were harvested from a local farm in Ayingba town, Kogi state, which is about 300 km from Abuja, the capital of Nigeria. The fruits were stored in a refrigerator at 10°c prior to use. The fruits were washed in clean tap water and the seeds were removed from the fruits. The seeds were cracked manually and separated from the hulls. The kernels were cut into thin slices of 1cm thickness and then sun-dried at 30±2°C to constant weight. The dried slices were milled in attrition mill and sieved through a 60 mesh sieve (British standard). The flour was packed in high density polyethylene bags prior to use. The pulp, fresh kernel and flour were analyzed for their proximate composition. The flour functional properties were also determined and compared with those of wheat flour.

Analytical methods

Chemical evaluation

Moisture was determined by hot air oven drying at 105°C to constant weight (AOAC, 2010). Ash, protein (micro-Kjeldahl, N ×6.25), crude fiber and fat (solvent extraction) were determined by the AOAC (2010) methods. Calorie was calculated using Atwater factors of 4 × % protein, 4 × % carbohydrate and 9 × % fat and then taking the sum.

Evaluation of functional properties

Bulk density was determined as described by Okaka and Potter (1977). Water and oil absorption capacities of flours (as is basis) were determined of room temperature following the method of Sosulski *et al*., (1976). Emulsion activity and emulsion stability were determined by the method of Okaka and Potter (1977). Foaming capacity (FC) and foam stability (FS) were measured by the method of Sathe *et al* (1982). The volume of foam at 30 sec of whipping was expressed as FC. The volume of foam was recorded one hour after whipping to determine FS as percent of the initial foam volume. The least gelation concentration was determined as described by Okaka and Potter (1977).

Statistical analysis

Data were analyzed using analysis of variance (Steel and Torrie, 1980). Means where significant were separated by the least significant difference (LSD) test. Significance was accepted at $P < 0.05$). Student t- test was used for paired comparison (Steel and Torrie, 1980)
Analyses were carried out in 3 replicates.

RESULTS AND DISCUSSION

Proximate composition

The proximate composition of African star apple as compared with wheat flour is given in Table 1. The pulp contained 35% moisture which was higher than the 20% for the fresh kernel. The moisture decreased to 9% in the flour following drying, a value which was lower than the 11% for wheat flour. Chukwumalume *et al*., (2010) have reported 31.97% moisture content for the pulp. Moisture content of foods is influenced by type, variety and storage condition (Enwere, 1998). The moisture content of African star apple kernel flour (ASAKF) was within the acceptable limit of not more than 10% for long term storage of flour(Onimawo and Akubor, 2012). The low moisture content of the flour would enhance its storage stability by preventing mould growth and reducing moisture dependent biochemical reactions (Onimawo and Aklubor, 2012). The pulp also contained more ash than the fresh kernel. The ash contents of the pulp and the fresh kernel were 4 and 2.5%, respectively. High proportion of the minerals in the apple may have been dissolved in the water contained in the pulp. Drying concentrated the ash to 3.8% in the flour. This ash level was higher than that of wheat flour which was 1%.

Table1: Proximate composition (fresh basis) of African star apple flour

Composition	Pulp	Fresh kernel	Kernel flour	Wheat flour
Moisture (%)	35.0± 0.71[a]	20.0±0.25[b]	9.0±0.07[d]	11±0.34[c]
Ash (%)	4.0±0.03[a]	2.5± 0.08b	3.8±0.08[a]	1.0±0.08[c]
Crude protein (%)	2.0± 0.010[d]	3.5± 0.07[c]	4.5±0.05[b]	11.5±0.14[a]
Crude fat (%)	2.2± 0.09[c]	8.4±0.01[b]	9.3±0.09[a]	1.5±0.05[d]
Crude fiber(%)	5.0± 0.08[a]	2.0± 0.03[b]	2.8±0.04[b]	0.6±0.01[c]
Carbohydrate (%)	52.0± 0.23[d]	63.6± 0.14[c]	70.6±0.15[b]	74.9±0.18[a]
Energy (Kcal /100g)	235.8± 0.15[d]	344.0±0.28[c]	384.1±081[a]	359.1±0.24[b]

Values are means ± SD of 3 replications. Means within a row with the same superscript were not significantly different (P > 0.05),

Table 2: Functional properties of African star apple kernel and wheat flours

Parameters	Star apple kernel flour	Wheat flour
Bulk density (g/ml)	0.74±0.05	0.68±0.02
Water absorption capacity (%)	250.0±0.81	130.0±0.75
Oil absorption capacity (%)	167.0±0.34	135.0±0.64
Emulsion activity (%)	5.8±0.03	30.0±0.14
Emulsion stability (%)	10.0±0.09	25.0±0.09
Foaming capacity (%)	20.0±0.14	40.0±0.18
Foam stability (%)	80.0±0.48	75.0±0.25
Least gelation concentration (%, w/v)	10.0±0.01	8.0± ± 0.03

Values are means ± SD of 3 replications. Means within a row with the same superscript were not significantly different (P > 0.05).

Ash is an indication of the mineral content of a food. The protein, on the other hand, was concentrated more in the kernel than in the pulp .The kernel contained 3.5% protein while the pulp had 2% protein. Fruit pulps are not generally high in protein (Enwere, 1988). The protein content of the flour which was 4.5**%** and improved over those of the kernel and pulp due to concentration effect. However, the protein content of the flour was significantly lower than the 11.5% for the wheat flour. The protein content and quality of the ASAKF could be improved by blending ASAKF with wheat flour as has been documented for many composite flours. Similarly, the kernel had 8.4% fat which was slightly higher the 2.2% fat for the pulp. Fruit pulps are not good sources of fat (Onimawo and Akubor, 2012). Similar fat content was previously reported for the kernel (Madubuike and Ogbonnaya, 2001).Drying the kernel also concentrated the fat content of flour from 4.4 to 9.3%, a value which was significantly higher than 1% for wheat flour .The ASAKF contained 2.8%, which was significantly($p<0.05$) lower than 5% for the pulp but higher than 2.0% for the fresh kernel . The crude fiber content of the ASAKF was significantly higher than that of 0.6% for wheat flour. The therapeutic effects of fiber in the prevention of heart diseases, colon cancer and diabetes and their role in the treatment of digestive disorders (diversticulosis) and constipation are widely documented (Anderson et al., 1994). The flour contained 384.1 kcal/100g energy. This value was higher than 235.8 kcal /100g for the pulp 344kcal / 100g for the kernel due to its higher contents of fat, carbohydrate and protein. The energy value of the flour was also higher than that of wheat flour which was 359.1 kcal/100g because of the higher fat content of the flour.

Functional properties

The functional properties of flours play important role in the manufacturing of products. The functional properties of African star apple kernel flour (ASAKF) and wheat flour are presented in Table 2. The bulk density of ASAKF which was 0.74 g/ml was not significantly different ($P>0.05$) from 0.64g/ml for the wheat flour. The bulk density of ASAKF was slightly higher than 0.51 g/ml reported for orange seed kernel flour (Akpata and Akubor, 1999) but lower than 0.81g/ml for buckwheat flour (Baljeet *et al*., 2010) and 1.12 g/ml for cola milinii seed flour (Akpata and Miachi, 1999). Bulk density is a function of particle size, particle size being inversely proportional to bulk density (Onimawo and Akubor, 2012). The differences in the particle size may be the cause of variations in bulk density of flours. Bulk density is an indication of the porosity of a product which influences package design and could be used in determining the type of packaging material required, material handling and application in wet processing in the food industry (Kinsella, 1987). Bulk density is also important in infant feeding where less bulk is desirable. The low bulk density of

ASAKF would an advantage in the use of the flour for preparation of complementary foods.

The water absorption capacity of 250% for ASAKF was significantly higher ($p<0.05$) than 130% for wheat flour. The ASAKF may have contained more hydrophilic constituents than wheat flour, which gave rise to higher water absorption capacity (WAC) .The ASAKF contained more crude fiber than wheat flour (Table 1). The lower moisture content of ASAKF also enhanced its WAC. Water absorption of flour is dependent mainly on the amount and nature of the hydrophilic constituents and to some extent on pH and nature of the protein (Gordon, 1993). Water absorption characteristic represents the ability of the product to associate with water under conditions when water is limiting such as doughs and pastes. The result of this study suggests that ASAKF would be useful in foods such as bakery products which require hydration to improve handling characteristics.The ASAKF (167%) also had higher oil absorption capacity (OAC) than wheat flour (135%). The OAC of ASAKF was higher than 49% reported for orange seed flour (Akpata and Akubor, 1999) and 70% for cola *milinii* (Akpata and Miachi, 1999) but lower than 181. 37% for buckwheat flour (Baljeet et al, 2010). The higher OAC suggested the presence of apolar amino acids in ASAKF (Sathe et al., 1982). Oil absorption capacity is attributed mainly to the physical entrapment of oils. It is an indication of the rate at which protein binds to fat in food formulations (Onimawo and Akubor, 2012). OAC is useful in formulation of foods such as sausages and bakery products (Akubor and Eze, 2012) and this shows that ASAKF would be useful in this respect. Fat acts a flavour retainer and increases the mouth feel of foods. Fat increases the leavening power of the baking powder in the batter and improves the texture of the baked product.

Emulsion characteristic of proteins contributes much to their functionality in foods. The emulsion activity and emulsion stability ASAKF were 5.8% and 10%, respectively. These values were low when compared to the emulsion activity of 30% and emulsion stability of 25% for wheat flour. The low emulsion properties of ASAKF may be ascribed to its low protein content and high content of insoluble components such as crude fiber that discouraged the formation and stabilization of emulsion (Kinsella, 1976). It may also be related to the type of protein in ASAKF .Soluble proteins are surface active and promote formation of oil-in-water emulsion (Onimawo and Akubor, 2012). The low emulsion properties of ASAKF may affect its suitability for certain functions such as stabilizing colloidal food systems.

The ASAKF had low faming capacity of 20% when compared to 40% for wheat flour. However, foams prepared from ASAKF which had a value of 70% were stable in relation to foam stability of 80% for wheat flour. The foam stability of ASAKF was higher than the 20% reported for fluted pumpkin seed (Fagbemi and Oshodi, 1991) and 36% for orange seed four (Akpata and Akubor, 1999).Foamability of a food material varies with the type of protein, solubility and other factors (Akubor and Eze, 2012).

Good foamability is linked with flexible protein molecule that could reduce surface tension while highly ordered globular protein which is relatively difficult to surface denaturation gives low foamiability (Onimawo and Akubor, 2012). Native protein has been shown to give higher foam stability than denatured protein (Sathe et al, 1982). This suggests that ASAKF contained reasonable amount of native proteins. Foams are used to improve texture, consistency and appearance of foods (Akubor and Eze, 2012). The ASAKF may find applications in baked and confectionery products.

The least gelation concentration of ASAKF was 10% (w/v) and that of wheat flour was 8% (w/v). The least gelation concentration reported for orange seed flour (Akpata and Akubor, 1999) and fluted pumpkin seed from (Fagbemi and Oshiodi, 1991) were 16 and 36% (w/v), respectively. The least gelation concentration varies for different flours. Sathe *et al*., (1982) associated the variations in the gelling properties of different flours different ratios of protein, carbohydrate and lipids that make up the flours. Interaction among these components play a significant role in functional properties as it affects gelation. Flour with low value of least gelation concentration could be a good thickening agent. The ASAKF would be useful in food systems such as puddings and snacks which require thickening and gelling. The gel structure of such food systems provides a matrix for retaining moisture, fat and other added ingredients.

CONCLUSION

This study has characterized the chemical and functional properties of African star apple kernel flour (ASKAP).

The flour contained higher contents of ash, fat and fiber than wheat flour. The amounts of crude protein and carbohydrate were lower in the ASAKF than in wheat flour. The ASAKF possessed higher water absorption capacity and oil absorption capacity than wheat flour. However, the emulsion and foaming properties of ASAKF were low in relation to those of wheat flour. The various capacity tests showed that ASAKF has the potential for incorporation into food formulations as a functional ingredient. However, more studies should be conducted to investigate the possibility of using ASAKF as a functional ingredient in food products such as biscuits, bread, cakes and complementary foods.

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