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Functional Properties and Mineral Contents of a Nigerian Okra Seed (*Abelmoschus esculentus* Moench) Flour as Influenced by Pretreatments

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Abstract: Studies on the mineral compositions and the functional properties of Nigerian okra seed (*Abelmoschus esculentus* Moench) flour were carried out. This was investigated in order to widen the scope of utilization of the seeds. The varying pretreatments given to okra seeds were soaking, blanching, malting and roasting following standard methods reported in literature. Pretreatments of okra seed had effect on the mineral and the functional properties of the flour. Soaking reduced all mineral investigated and are time dependent. Blanching reduced all mineral content except Magnesium. Malting reduced P, K, Mg and Fe, while increase in Ca, Na, Zn and Mn were observed. Roasting increased all the mineral content except Phosphorus and Magnesium. Functional properties showed that all pretreatments resulted into increase in water and oil absorption capacities, decrease in emulsion ability and stability and decrease in foam capacity and stability except malting, which shows an increase in foam capacity and stability.

Key words: Okra seeds, soaking, blanching, germination, roasting, functional properties, mineral contents

INTRODUCTION

Okra (*Abelmoschus esculentus* Moench) is specially valued in different parts of Nigeria for its delicious fruits and it is consumed alone or in combination with other foods. Nutritionally, the richest part of okra plants is the dried seed (Adelakun *et al*., 2009). Presently in Nigeria, the seed is limited to re-generational purpose. As such, farmers only plant for seedling and re-generational purposes, while large quantities of the seeds are discarded as unfit for seedling purposes hence, post harvest losses.

Food security remains a challenge in developing country like Nigeria. Guaranteeing food security involves intensifying agricultural production and provision of appropriate processing techniques. Pretreatments are techniques used in the treatment of raw material before proper processing. Such pretreatment may lead to an alteration of the basic structure or component of the raw material. Vegetables are frequently subjected to various forms of processing to make them more suitable for consumption as well as more resilient to long term storage (Volden *et al*., 2008). This study was undertaken to assess the influence of pretreatment on some minerals and functional properties of okra seed flour.

MATERIALS AND METHODS

Lady finger variety of okra seeds (*Abelmoschus esculentus*) (locally known as *Iwo agbonrin*) were procured from National Institute of Horticulture, Idi Ishin (NIHORT), Oyo state, Nigeria and given to breeders to multiply and to prevent adulteration. The seeds were then cleaned in preparation for the study.

- Pre-treatment of okra seeds by soaking was prepared by the method of Adeyemi (1988)
- Pre-treatment of okra seeds by blanching was prepared according to the method of Ade-Omowaye *et al*. (2003)
- Pre-treatment of okra seeds by malting was by Wang and Field (1978)
- Pre-treatment of okra seeds by roasting (Adebiyi *et al*., 2002)
- Preparation of okra flour was prepared by method of Adelakun *et al*. (2009)

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The pretreated okra seed flour samples were designated as soaked, malted, blanched or roasted flour.

Determination of mineral contents: The method described by AOAC (1990) using Atomic Absorption Spectrophotometer (AAS) Buck Scientific East Norwalk, CT, USA was used for mineral contents determination. Minerals that were determined are Phosphorus, Potassium, Calcium, Magnesium, Sodium, Iron, Copper, Zinc and Manganese (P, K, Ca, Mg, Na, Fe, Cu, Zn and Mn). The analyses were in replicates.

Determination of functional properties:

- Foaming Capacity (FC) and Foam Stability (FS) by method of Narayana and Narasinga (1982)
- Determination of water and oil absorption capacities were determined by the method of Sosulski *et al.* (1976)
- Emulsion activity and stability were determined by the method of Lin *et al.* (1974)

Statistical analysis: The data recorded on the sample were statistically analyzed using the Statistical Analysis Software (SAS) package (version 8.2 of SAS Institute, inc.). Statistically significant differences ($p<0.05$) in the mineral and functional properties of the samples were determined by one way ANOVA (SAS, 1999).

RESULTS AND DISCUSSION

Effect of pretreatments on some mineral contents of okra seed flour: This study show that okra seeds contained appreciable quantities of both major and minor minerals although, soaking and blanching significantly reduced ($p<0.05$) the entire mineral investigated (Table 1). The decreases in all the mineral contents were observed to be progressive as soaking and blanching time increases. Leaching into the soaking and blanching water could have occurred since the water was discarded some mineral could have been lost (Adeparusi, 2001). Significant differences ($p<0.05$) were also noticed in the raw sample and the entire individual mineral analyzed except magnesium, which were not significantly different from each other and calcium, which were not significantly different from the raw sample in the blanched samples.

These minerals were relatively high when compared with those of jack bean as reported by Agbede and Aletor (2005). Higher levels of the minerals were observed for the

Table 1: Effect of pretreatments on some mineral contents of okra seed flour

Treatments	Duration	P	K	Ca	Mg	Na	Fe	Cu	Zn	Mn
		$(mg\ kg^{-1})$								
Soaking	**Period (h)**									
S0	0	24.01a	34.42a	1.88a	12.65a	20.74a	322.43a	35.43a	158.94a	248.98a
S1	6	19.23b	33.65a	1.68b	11.22b	17.73b	136.14b	17.63b	163.9b	177.48b
S2	12	18.94b	30.06b	1.73b	10.04c	17.34c	120.46c	16.84b	129.46c	132.22c
S3	18	18.1bc	28.28c	1.58b	9.67c	16.15d	100.26d	16.34bc	114.67d	121.50d
S4	24	17.52c	27.18c	1.46bc	9.15c	15.63e	93.38e	12.87d	109.83e	119.00e
S5	36	15.33d	26.84cd	1.34c	9.09cd	14.21f	77.62f	10.02e	102.67f	91.75f
S6	48	14.16d	24.65d	1.33c	9.08cd	14.73g	69.52g	9.31e	97.6g	87.98g
Blanching	**period (min)**									
B0	0	24.01a	34.42a	1.88a	12.65a	20.74a	322.43a	35.43a	158.94a	248.98a
B1	10	13.39b	22.50b	1.49a	9.12b	16.85b	134.58b	15.56b	122.61b	135.7b
B2	20	12.67b	21.4c	1.52a	9.1b	16.76b	112.79c	14.83b	98.10c	93.98c
B3	30	12.50b	20.5c	1.67a	9.08b	15.68c	77.16d	13.27c	67.64d	69.66d
B4	40	12.38bc	19.30cd	1.71a	9.07b	12.51d	68.5e	10.76d	46.52e	60.22e
B5	60	12.33bc	17.57e	1.71a	9.07b	12.34d	44.19f	10.07d	45.65e	57.55f
Malting	**Period (days)**									
M0	0	24.01a	34.42a	1.88bc	12.65a	20.74b	322.43a	35.43e	158.94f	248.98f
M1	1	16.76b	26.85b	1.76bc	10.74b	19.01c	269.26b	68.65c	163.68e	249.21e
M2	2	15.05b	26.62b	1.9abc	10.73b	18.06d	197.95c	65.28d	187.31d	258.56d
M3	3	13.89bc	25.06c	1.94ab	10.21b	18.16d	180.16d	73.8b	192.31c	272.6c
M4	4	13.66c	24.16d	1.97a	10.39b	16.30e	130.5e	73.01b	211.92b	274.29b
M5	5	13.34c	24.60d	2.12a	10.70b	22.51a	112.83f	75.21a	213.26a	278.43a
Roasting	**Period (min)**									
R0	0	24.01a	34.42a	1.88b	12.65a	20.74c	322.43e	35.43cd	158.94e	248.98e
R1	10	21.63b	34.79a	1.95ab	11.65b	20.42d	379.2b	36.55c	241.58d	292.83d
R2	20	20.42c	35.09a	2.02a	11.78b	20.34e	367.78d	36.33c	348.10c	393.98c
R3	30	20.42c	35.29a	2.08a	11.82b	20.81b	377.16c	43.27b	367.64b	469.66b
R4	40	20.09c	35.46a	2.35a	11.85b	20.96a	460.25a	69.88a	387.00a	506.75a

Values are means of three determinations, values with the same letter in the same column are not significantly different ($p<0.05$), S0, B0, M0 and R0: Raw okra seed; S1: Okra seed soaked for 6 h; S2: Okra seed soaked for 12 h; S3: Okra seed soaked for 18 h; S4: Okra seed soaked for 24 h; S5: Okra seed soaked for 30 h; S6: Okra seed soaked for 48 h; B1: Okra seed blanched for 10 min; B2: Okra seed blanched for 20 min; B3: Okra seed blanched for 30 min; B4: Okra seed blanched for 40 min; B5: Okra seed blanched for 60 min; M1: Okra seed malted for 1 day; M2: Okra seed malted for 2 days; M3: Okra seed malted for 3 days; M4: Okra seed malted for 4 days; M5: Okra seed malted for 5 days; R1: Okra seed roasted for 10 min; R2: Okra seed roasted for 20 min; R3: Okra seed roasted for 30 min; R4: Okra seed roasted for 40 min raw seeds over the soaked samples under study, which is also time dependent, thus corroborating the reports of Apata and Ologhobo (1990); Agbede and Aletor (2005). Of major nutritional significance in these seeds is the relatively low content of sodium and potassium in the soaked seed flours when compared to some grain cereals as reported by Ragaee *et al*. (2006). This is important since high dietary sodium is implicated in cardiovascular and renal disorders. Consequently, high dietary sodium is often discouraged in subjects who suffer from or are prone to hypertension. Similarly, Ca, P and Mg required for bone mineralization are relatively high in this seed.

For malted samples, significant decrease ($p<0.05$) were observe for P, K, Mg and Fe, while a significant increase ($p<0.05$) were observed for Ca, Na, Cu, Zn and Mn. Most of the increment was in the trace mineral (Table 1). Initial soaking for 24 h could have led to the decrease of some of the mineral investigated by leaching and subsequent increment of some could be as a result of the conversion of the insoluble reserve foods by enzymes during germination (Rooney and Serna-Saldivar, 1990). Trace heavy metals are significant in nutrition for their essential nature or their toxicity. Copper and Zinc are known to be essential and may enter food materials from soil through mineralization by crops, food processing or environmental contamination, as in the application of agricultural inputs, such as copper-based pesticides, which are in common use in farms in some countries (Onianwa *et al*., 2001).

Cu is essential as a constituent of some metallo enzymes and is required in haemoglobin synthesis and in the catalysis of metabolic oxidation (Underwood, 1977). Symptoms of copper deficiency in human include bone demineralization, depressed growth, depigmentation and gastro-intestinal disturbances among others, while toxicity due to excessive intake has been reported to cause liver cirrhosis, dermatitis and neurological disorders (Graham and Cordano, 1976; Lucas, 1974). Zn is essential as a constituent of many enzymes involved in a number of physiological functions, such as protein synthesis and energy metabolism. Zinc deficiency, resulting from poor diet, alcoholism and malabsorption, causes dwarfism and dermatitis, while toxicity of zinc, due to excessive intake, may lead to electrolyte imbalance, nausea, anaemia and lethargy (Fairweather-Tait, 1988; Prasad, 1984).

The result of the effect of roasting and roasting time on the mineral composition is shown in Table 1. Unlike, most of the pretreatment, roasting resulted into an increase in all the minerals analysed but for Phosphorus and Magnesium. Increment range of 1.06-3.02, 3.72-25, 1.11-1.92, 14.06-42.74, 2.54-97.23, 52-143.5 and 27.59-103.53% were obtained for Potassium, Calcium, Sodium, Iron, Copper, Zinc and Manganese, while a loss range of 9.95-16.36 and 6.39-7.98% were recorded for phosphorus and magnesium, respectively. Digestibility of nuts and oilseeds are reported to increase by roasting, this might be responsible for the release and increment in mineral content investigated (Mohini and Eram, 2005).

Effect of pretreatment on the some functional properties of the okra seed flour: The results of the functional properties determined are shown in Table 2. The Water Absorption Capacity (WAC) varies from 241% in raw dried okra seed flour to 267% in soaked okra seed flour. The Oil Absorption Capacity (OAC) also varies from 229.4% in the raw dried okra seed flour to 253.5% after soaking for 48 h. Results show that pretreatment by soaking significantly ($p<0.05$) increased the WAC and the OAC. The improved WAC and OAC may be due to increases solubility and could be explained by proteolytic activity of micro-organisms, which produces soluble oligopeptides.

Soaking significantly reduced Emulsion Activity (EA) of raw okra seed flour (44%) from the soaked samples (43.5-35.5%). Emulsion capacity and stability were reduced by fermentation, which occurred in the soaked samples. Invariably this may lower its functionality in terms of use in preparing commuted meats like sausages, cake buffers, mayonnaise and salad dressing (Akubor *et al*., 2000). Foam capacity and stability were significantly reduced by soaking.

The Water Absorption Capacity (WAC) and Oil Absorption Capacity (OAC) of raw okra seed flour are 241.5 and 229.4%, respectively (Table 2). The WAC and OAC were observed to increase from 248.2-69.5 and 235.7-256%, respectively after blanching time was increased from 10-60 min. Results show that blanching significantly increased the WAC and OAC of okra seed flour. The OAC of the blanched okra seed flours are >89.7% reported for pigeon pea flour by Oshodi and Ekperigin (1989). Lin *et al*. (1974) reported similar observations with sunflower, whose water imbibing and oil absorption capacities were enhanced by heating (denaturation).

Water holding capacity also known as water absorption capacity denote the maximum amount of water that a food material can take up and retain under formulation condition, which is also known to be related to the degree of dryness and porosity (Oyelade *et al*., 2002; Alkpapunam and Achinewhu, 1985). The increase in WAC observed agrees with an earlier research, which indicated that pre-gelatinization, which is a form of blanching positively influence the water holding capacity of maize flour (Adeyemi *et al*., 1989). Partial protein denaturation and starch gelatinization, which occurred

Table 2: Effect of pretreatments on some functional properties of okra seed flour

Treatments	Duration	WAC	OAC	EA	ES	FC	FS
Soaking	**Period (h)**						
S0	0	241.6g	229.4g	44.0a	30.5a	21.0a	13.0a
S1	6	243.6f	231.3f	43.5a	29.0b	17.0b	12.5b
S2	12	244.0e	231.7e	41.5b	27.5c	15.5c	10.5c
S3	18	243.8d	231.5d	38.5c	27.0c	13.5d	10.0d
S4	24	251.8c	239.1c	37.5d	26.5d	12.5e	8.0e
S5	36	258.5b	245.5b	36.5e	25.0e	9.0f	7.0f
S6	48	267.0a	253.5a	35.5f	24.0f	6.0g	65.0g
Blanching	**Period (min)**						
B0	0	241.6f	229.4f	44.0a	30.5a	21.0e	13.0a
B1	10	248.2e	235.7e	43.5b	28.5a	23.0d	13.0a
B2	20	251.2d	238.5d	42.5c	28.0ab	25.0c	12.0b
B3	30	254.5c	241.7c	41.5d	27.5b	26.0b	12.0b
B4	40	258.2b	245.2b	42.5c	26.5c	26.0b	11.0c
B5	60	269.5a	256.0a	42.5c	25.5d	29.0a	11.0c
Malting	**Period (days)**						
M0	0	241.6f	229.4f	44.0c	30.5a	21.0e	13.0d
M1	1	243.6e	231.4e	44.5b	30.5a	25.0c	13.5c
M2	2	250.2d	237.65d	44.5b	30.0b	25.5c	14.0b
M3	3	252.7c	240c	45.0a	30.0b	27.5b	13.5c
M4	4	255.7b	242.85b	44.5b	30.0b	28.0b	14.5a
M5	5	259.9a	246.8a	44.0c	29.0c	30.5a	14.5a
Roasting	**Period (min)**						
R0	0	241.6e	229.4e	44.0a	30.5a	21.0a	13.0a
R1	10	244.3d	232.0d	44.5a	29.5a	13.0b	9.0b
R2	20	252.4c	239.75c	40.5b	25.5b	11.0c	6.0c
R3	30	258.0b	245.0b	36.0c	21.0c	5.5d	5.5d
R4	40	264.9a	251.6a	35.5c	16.5d	5.0d	5.0d

Values are means of three determinations, values with the same letter in the same column are not significantly different ($p<0.05$), S0, B0, M0 and R0: Raw okra seed; S1: Okra seed soaked for 6 h; S2: Okra seed soaked for 12 h; S3: Okra seed soaked for 18 h; S4: Okra seed soaked for 24 h; S5: Okra seed soaked for 30 h; S6: Okra seed soaked for 48 h; B1: Okra seed blanched for 10 min; B2: Okra seed blanched for 20 min; B3: Okra seed blanched for 30 min; B4: Okra seed blanched for 40 min; B5: Okra seed blanched for 60 min; M1: Okra seed malted for 1 day; M2: Okra seed malted for 2 days; M3: Okra seed malted for 3 days; M4: Okra seed malted for 4 days; M5: Okra seed malted for 5 days; R1: Okra seed roasted for 10 min; R2: Okra seed roasted for 20 min; R3: Okra seed roasted for 30 min; R4: Okra seed roasted for 40 min, Water Absorption Capacity (WAC); Oil Absorption Capacity (OAC); Emulsion Activity (EA); Emulsion Stability (ES); Foam Capacity (FC); Foam Stability (FS)

during heat treatment, could all be responsible for the increased water holding capacity of okra seed flour. The increase in water holding capacity has been attributed to the increased amount of starch damaged during heat treatment (Kurimoto and Shelton, 1988; Ade-Omowaye *et al*., 2003; Cuevas-Rodriguez *et al*., 2006). Heat processing of bean flours had been reported to result in higher water absorption capacities than raw flours (Narayana and Narasinga, 1982).

The mechanism of oil absorption may be explained as a physical entrapment of oil related to the non polar side chains of proteins. Nature of primary structure and conformational features, hydrophobic amino acid concentrations and protein content all contribute to the oil-retaining properties of food materials. Any processing method that influences these parameters would tend to influence the oil absorption characteristics of the food system (Njintang *et al*., 2001). The micro-porous nature of the blanched products may also expose more proteins to the surface to interact with oil. The observed effect of blanching suggests that all these factors may have influenced the nature of proteins in okra seed. The blanched okra seed flour may be useful in ground meat formulations, meat replacers and extenders, pancakes and baked goods, where oil holding capacity is of prime importance. This blanched product with higher water absorption capacity will also acquire the property of dissolving and swelling easily in cold water and find useful applications in preparation of instant foods such as soups and other premixes providing convenience to the user (Mohini and Eram, 2005).

Raw okra seed flour had Emulsion Activity (EA) and Emulsion Stability (ES) of 44 and 30.5%, respectively. These values are lower to the reported EA values for green gram, cowpea, lentil and chickpea (48-54%) (Ghavidel and Prakash, 2006). However, blanched okra seed flour had lower EA and ES than the un-blanched sample. These EA were observed to be significantly difference ($p<0.005$) than the un-blanched sample (Table 2). Results show that blanching at 30-60 min brought about significant decrease in ES of okra seed flour while, those blanched for 10-20 min had comparable values with the raw dried sample. EC and ES are important considerations in the production of pastries, coffee whiteners and frozen desserts. ES is an important functional property of the flour, which helps in fat/water phase stability in many baked food products.

The Foam Capacity (FC) and Foam Stability (FS) of raw and blanched okra seed flour as presented in Table 2 shows that FC varied from 21% in raw okra seed to 23-29% in blanched okra flour, while FS varied from 13% in raw okra seed flour to 13-11% in blanched samples. Results showed significant increase in the FC and decrease in FS of blanched okra seed flour compared with the raw dried seed flour. Thus, this flour having lowest Foaming Stability (FS) showed inverse relationship with the FC.

Flours with high foaming ability could form large air bubbles surrounded by thinner and less flexible protein films. These air bubbles might be easier to collapse and consequently lowered the foaming stability. On the other hand, flours with low FC could bring about the formation of smaller air bubbles surrounded by thicker and more flexible protein films, which discouraged the coalescence of air bubbles and consequently increased the foaming stability (Jitngarmkusol *et al*., 2008). Blanched okra seed flours may be suitable in food system that requires foaming such as cake and ice cream. The ability to form stable foams is an important property in whipped toppings, frozen desserts and sponge cakes thus, blanched okra seed flour can find use in these formulations since it is relatively stable (Fasasi and Oyareku, 2007; Yu *et al*., 2007).

The WAC and OAC were observed to increase from 243.6-259.9% and 231.4-246.8%, respectively after malting time was increased from 1-5 days. The high WAC associated with germinated okra seed flour may be due to changes in the quality and quantity of proteins upon germination (Del Rosario and Flores, 1981) also modification (via germination) may also lead to higher OAC. This observation is consistent with the reports of Padmashree *et al*. (1987) and Pawar and Ingle (1988) who reported increase in the WAC and OAC of germinated cowpea and mothbean flours, respectively.

Untreated okra seed flour had Emulsion Activity (EA) and Emulsion Stability (ES) of 44 and 30.5%, respectively. Malting of okra seed resulted into slightly higher EA (1-3 days) and reduced slightly from 4-5 days. Lower ES were observed in malted samples and these were observed to reduce as malting time increased (Table 2). Moreover, germinated okra seed flour had comparable values of EA and ES with the raw dried sample.

The Foam Capacity (FC) varied from 21% in raw okra seed to 25-30.5% in malted okra flour, while Foam Stability (FS) varied from 13% in raw okra seed flour to 13-14.5% in malted samples. Results showed significant increase in the FC and FS of malted okra seed flour compared with the raw dried seed flour. Mahajan *et al*. (1999) had similar observations with germinated rapeseed meals.

The WAC and OAC were observed to increase from 244.3-264.9 and 232-251.6%, respectively after roasting time was increased from 10-40 min. Results show that roasting significantly increased the WAC and OAC of okra seed flour. The OAC of the roasted okra seed flour is >89.7% reported for pigeon pea flour by Oshodi and Ekperigin (1989). Lin *et al*. (1974) reported similar observations with sunflower, whose water imbibing and oil absorption capacities were enhanced by heating (denaturation). Popping (heat) process was also reported to significantly enhance the OAC of horse gram flour (Sreerama *et al*., 2008). The roasted okra seed flour may be useful in ground meat formulations, meat replacers and extenders, pancakes, baked goods and soups, where oil holding capacity is counted as importance.

Raw okra seed flour had Emulsion Activity (EA) and Emulsion Stability (ES) of 44 and 30.5%, respectively. These values are lower to the reported EA values for green gram, cowpea, lentil and chickpea (48-54%) (Ghavidel and Prakash, 2006). However, roasted okra seed flour had lower EA and ES and these were observed to reduce as roasting time increased (Table 2). Results show that roasting at 20-40 min brought about significant decrease in EC and ES of okra seed flour, while those roasted for 10 min had comparable values with the raw dried sample. This report is in consonance with that reported by Fasasi and Oyeraku (2007) who observed a reduction in the EC of roasted bread fruit seed flour but contrary to that reported by Sreerama *et al*. (2008), who observed increase in the EC and ES of popped horse gram flour. EC and ES are important considerations in the production of pastries, coffee whiteners and frozen desserts. ES is an important functional property of the flour, which helps in fat/water phase stability in many baked food products.

FC varied from 21% in raw okra seed to 13-5% in roasted okra flour, while FS varied from 13% in raw okra seed flour to 9-5% in roasted samples. Results showed significant decrease in the FC and FS of roasted okra seed flour compared with the raw dried seed flour. The lower values associated with roasted flour may be due to high protein-protein interaction, leading to formation of aggregates detrimental to foam formation (Mcwatters and Cherry, 1977) and diminished nitrogen solubility due to denaturation (Yatsumatsu *et al*., 1972). The ability to form stable foams is an important property in whipped toppings, frozen desserts and sponge cakes thus, roasted okra seed flour cannot find use in these formulations.

CONCLUSION

From this study, it is said that okra seed is a promising food products and pretreatments such as soaking, malting, blanching and roasting resulted in some quality parameter enhancement of the resultant flour that were investigated. This research has also been able to widen the seeds' scope of utilization other than re-generational purposes, which it is known for. The data generated from this research could find useful application in different food formulations.

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