

THE EFFECTS OF PARTIAL DEFATTING, CHEMICAL TREATMENT AND AMBIENT STORAGE ON FUNCTIONAL PROPERTIES AND SHELF-STABILITY OF OGBONO (*IRVINGIA GABONENSIS*) FLOUR

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ABSTRACT

The kernel of dika nut, *Irvingia gabonensis* var. *excelsa*, locally known as *ogbono* was used in this research. Flour (sieve size 0.5mm) were prepared separately from defatted and undefatted *ogbono* kernels. Each of the flour samples was divided into four portions, and treated separately with different chemicals before packaging and storage. The first portion was treated with anticaking agent, the second with mold inhibitor, the third with a mixture of both anticaking and mold inhibitor, while the last batch was left untreated. The untreated samples served as control. Defatted samples did not turn rancid (FFA=5.91±0.22g/100g) as much as the undefatted samples (FFA =9.7±0.36g/10g). Fat and water absorption capacities were 1.62±0.48g/g and 7.49±1.71g/g respectively for defatted sample while they were 1.04±0.52g/g and 5.92±2.55g/g for the undefatted. Interestingly, the defatted *ogbono* flour maintained their functionality throughout the period of storage. Neither defatting nor the chemical treatments reduced the functionality of *ogbono* flour. Rather significant (P=0.05) extension of shelf-life, and improved functionality were observed. Production of defatted *ogbono* flour is recommended on the basis of convenience, shelf-stability as well as healthier heart benefits.

KEY WORDS: *Ogbono*, Defatting, Functional properties, shelf-life, Free fatty acid

INTRODUCTION

Ogbono, *agbono*, *Ogwi*, *apon* and *egili*, as known by the Igbos, Yorubas, Benin and Igala tribes of Nigeria respectively are the kernel of *Irvingia gabonensis* var. *excelsa*, a small mango like fruit sometimes called "Wildmango" or "dikanut". It belongs to the family: *Irvingiaceae* and it is of two varieties: *Irvingia gabonensis* var. *gabonensis* and *Irvingia gabonensis* var. *excelsa*. The kernels are widely marketed domestically, nationally and between countries in West Africa (Ndonye *et al.*, 1998). *Ogbono* produces hydrogel, hydrocolloids polymer, which dissolves in water to give a gelling effect. They also exhibit some related secondary functional properties, which are widely used in food product development. In Nigeria in particular, *ogbono* is well relished for their thickening properties, which are the basis for the *ogbono* soups and stews. The term "draw-soup" for *ogbono* reflects the ability of the mucilage to be drawn out in strings or tendrils and it is a trait of good quality (Ejiofor *et al.*, 1989, Ejiofor *et al.*, 1996) referred to the 'draw-ability' of the soup as a factor in sensory evaluation of the soup. *Ogbono* is the most powerful of all the African soup thickeners (Ladipo, 1996) as it impacts gummy texture (hydrogel), a desirable attribute for the eating of staple foods such as *garri*, (eba) pounded yam, cocoyam and *fufu*.

Ogbono kernel has short storage life because it is prone to fungal attack and development of rancidity (Leaky, 1998). Many preservation methods such as processing into cubes/pellets (Ejiofor, 1989), sundrying and storage in airtight jars or sacks (Ladipo, 1996), and storage over fire-places (Nwosu *et al.*, 2005) have been reportedly used to store *ogbono* for long period of time. However, extended storage has not been achieved with these methods, and this has hindered industrial use of this hydrogel-forming legume. High fat content coupled with little or no natural antioxidants such as vitamins E and C (Ihediohanma and Ijioma, 2005) could be part of the factors hindering long storage of *ogbono* kernel. The fat content of *ogbono* (65-70%) as reported by FAO (1998) is higher than soybean (19%) and groundnut (40%), which are the main vegetable oil sources in Nigeria except palm oil. Hence it will be necessary to assess the effect of partial defatting and/or chemical preservatives on functionality of *ogbono* flour over a period of time. The aspect of defatting is considered necessary for two major reasons. One is on

health ground, giving the fact that *ogbono* kernels do not only contain high content of fat, but the fat is composed of 89.7% saturated fatty acids (Ihediohanma and Ijioma, 2005). The fatty acid composition of *ogbono* is as follows: lauric (40.4%) myristic (42.75%), palmitic (6.56%), oleic (1.88%), capric (1.68%) stearic (2.2%) and linoleic (2.0%) (Eka, 1980, Hegstel *et al.*, 1993). Studies (Hegstel *et al.*, 1993, Zock *et al.*, 1994) have shown that myristic acid is the principal hypercholesterolemic saturated fatty acid followed by lauric while palmitic is only hypercholesterolemic when the cholesterol intake is already high (Chosca, 1993). Therefore defatting will help to reduce these saturated fatty acids and of course the extracted oil could be used for industrial making of products such as soap and waxes. The second reason for defatting of *ogbono* is that it will also reduce fat oxidation reactions (rancidity). This present investigation is aimed at promoting industrial use of *ogbono*. This is necessary especially now that Nigeria is interested in "non-oil" based sources of income. The processing of *ogbono* kernel into flour would also reduce the drudgery of housewives who would have to grind *ogbono* every now and then for soup making. Therefore, the objectives of this work were: (i) To examine the effect of defatting on shelf-life and functional properties of *ogbono* flour and (ii) To determine the effect of anticaking agent and antioxidant on shelf-life and functional quality of defatted and undefatted *ogbono* flour

MATERIALS AND METHODS

PREPARATION OF SAMPLES

Dried *ogbono* kernels used in this research were purchased from a local market in Owerri, Imo State, Nigeria. The kernels were ground to obtain flour using sieve size of 0.5mm. The flour obtained was sectioned into two parts. One part was partially defatted (20%) mechanically using locally fabricated manual screw press while the other was left undefatted. Both the defatted and undefatted samples were further subdivided into four portions: one portion was treated with 0.05% sorbic acid (mold inhibitor). The second part was treated with 0.05% ammonium bicarbonate (anticaking agent), the third with an equal mixture of anticaking agent and antioxidant while the last was left untreated (control). Each sample was duplicated five times so as to obtain enough samples for the five weeks shelf-life study.

ANALYSIS OF SAMPLE

Determination of Free fatty acid

The method of AOAC, (1993) was used for free fatty acid determination. Twenty five milliliters of diethyl ether was mixed with 25ml ethanol into 2g of the oil. Subsequently phenolphthalein was added (an indicator). It was titrated with 0.1N sodium hydroxide and shake constantly until a pink colour which persisted for 15s marked the end of the titration. Free fatty acid (as lauric acid) was given as acid value multiplied by two, where acid value was calculated thus

$$\text{Acid value} = ((X \times 20.0)/w)$$

X = volume in ml of 0.1N NaOH required for neutralization. w = weight in grams of oil
20.0 = constant factor

Determination of Oil and Water Absorption Capacities

The method of Beuchat (1977) was followed with slight modification for the determination of oil absorption. Flour samples weighing 1g each was measured out and mixed with 10ml turkey brand vegetable oil or water as the case may be for 1min by manual shaking. The samples were allowed to stand at room temperature for 30min and then centrifuged at 3000rpm (Hettich Universal) for 30min. The volume of the supernatant in a 10ml-graduated cylinder was noted. The mean of duplicate determinations was reported as gram oil absorbed or water per gram of protein.

Evaluation of shelf stability

For the shelf life study, each sample was packaged with black cellophane and coated with aluminium foil and kept on shelf for one month. Each week a set of sample were drawn for all the necessary analysis.

Experimental design and statistical analysis

This experiment was a three-factor treatment in a randomized complete block design (RCBD). It has fat content x 2, chemical treatment x 4 and storage period x 5 as sources of variation. Analysis of variance (ANOVA) using SAS on windows 2000 was used for statistical analysis while least significant difference (LSD) was used to separate the means.

RESULTS AND DISCUSSION

FUNCTIONAL PROPERTIES OF DEFATTED AND UNDEFATTED OGBONO FLOUR.

There was significant ($P=0.05$) difference between defatted and undefatted samples as shown in Table 1. Generally defatted samples exhibited higher functionality values than the undefatted. Fat absorption capacity was 1.62 ± 0.48 g/g in the defatted sample while it was 1.04 ± 0.52 g/g in the undefatted sample. The value obtained for water absorption capacity was 7.49 ± 1.71 g/g for defatted and 5.92 ± 2.55 g/g for undefatted samples. The observed differences could probably be because of the fact that the defatted sample had much more affinity for hydrophilic and hydrophobic interactions compared to undefatted sample as observed by Onweluzo *et al.* (1995). This could be as a result of a higher protein content (proportional) obtained in the defatted sample following a reduction in its fat content. This may confirm the claim that flour proteins (and to a lesser extent starch-cellulose) are mainly responsible for the water/oil uptake of flour at room temperature (Giami, *et al.*, 1994; Ohr, 2005). The implication of this is that the defatted flour will have a higher colloidal (hydrogel) capacity. A report by Okoro (2006) on the extraction of hydrogel from defatted and undefatted *ogbono* kernel disclosed a three-fold higher emulsion capacity in the defatted *ogbono* flour compared to the undefatted. The higher value obtained in the defatted flour could be as a result of increased protein content (proportional). Protein act as surface-active agent and lowers the interfacial tension between immiscible liquids, enabling a mixture of the two (Mcwaters and Brantly, 1982).

TABLE 1: FUNCTIONAL PROPERTIES OF DEFATTED AND UNDEFATTED OGBONO FLOUR

FUNCTIONAL PROPERTY	DEFATTED	UNDEFATTED	LSD
Water absorption capacity (g/g)	7.49 ± 1.71	5.92 ± 2.55	0.12
Fat absorption capacity (g/g)	1.62 ± 0.48	1.04 ± 0.52	0.06
Free fatty acid (g/100g)	5.91 ± 0.22	9.79 ± 0.36	0.02

EFFECT OF CHEMICAL TREATMENT ON FUNCTIONAL PROPERTIES OF OGBONO FLOUR

The chemical treatment caused a significant ($P=0.05$) difference among the samples in terms of water absorption capacity (WAC) (Table 2). The control sample had the lowest WAC for both defatted (6.32 ± 1.82 g/g) and undefatted (4.71 ± 0.48 g/g). Conversely samples treated with a mixture of mold inhibitor and anticaking agent had the highest WAC of 8.84 ± 1.14 g/g. In all cases the untreated sample had the lowest WAC, followed by those treated with mold inhibitor. For FAC, the highest ($P=0.05$) value of 1.76 ± 0.27 g/g was obtained in the defatted sample treated with a mixture of mold inhibitor and anticaking agent. Mold inhibitor treatment reduced the FAC of *ogbono* flour as shown in Table 2. This could be

because of the decrease in the hydrophilic polar ends, which made it difficult to bind with fat. The anticaking agent increased the free fatty acid (FFA) of *ogbono* flour compared to the other treatments. The reason may be because of the hygroscopic nature of this chemical which might have made it to attract moisture from the environment into the sample. Presence of moisture might have promoted mold growth and the subsequent triglyceride hydrolysis (<http://www.oregunstate.edu/instrut/>) leading to FFA development. The lowest percentage of FFA ($5.90 \pm 0.12\%$) occurred in the sample treated with mold inhibitor. This was obviously because of the oxygen scavenging ability of mold inhibitor.

TABLE 2: EFFECT OF CHEMICAL TREATMENT ON DEFATTED AND UNDEFATTED OGBONO FLOUR

CHEMICAL TREATMENT	DEFATTED			UNDEFATTED		
	WAC (g/g)	FAC (g/g)	FFA (g/100g)	WAC (g/g)	FAC (g/g)	FFA (g/100g)
Untreated	6.32 ± 1.82	1.68 ± 0.69	6.33 ± 0.21	4.71 ± 0.48	1.10 ± 0.51	9.64 ± 0.48
Anticaking	7.50 ± 1.81	1.41 ± 0.31	7.05 ± 0.28	6.77 ± 2.21	1.14 ± 0.48	9.78 ± 0.43
Antioxidant	7.31 ± 1.42	1.63 ± 0.51	5.90 ± 0.12	5.56 ± 2.68	0.93 ± 0.52	7.02 ± 0.01
Mixture	8.84 ± 1.14	1.76 ± 0.27	6.47 ± 0.22	6.62 ± 3.51	0.98 ± 0.51	7.25 ± 0.24
Mean	7.49	1.62	6.44	5.92	1.04	8.42
LSD	0.18	0.10	0.03	0.18	0.10	0.03

Mixture = equal combination of antioxidant and anticaking agent

FAC= Fat absorption capacity
 WAC= Water absorption capacity
 FFA= Free fatty acid

EFFECTS OF DEFATTING AND PERIOD OF STORAGE ON FUNCTIONAL PROPERTIES OF OGBONO FLOUR.

The result of fat absorption capacity (FAC) for the defatted and undefatted samples during storage is shown in Table 3. FAC for the defatted sample increased from 1.73 ± 0.29 g/g to a maximum value of 1.98 ± 0.32 g/g during the third week of storage. Afterwards, the value decreased until the end of the storage. Undefatted *ogbono* flour followed a similar trend with a gradual increase from 1.15 ± 0.38 g/g during the first week to a maximum value of 1.61 ± 0.25 g/g at the third week, and decreased to 0.28 ± 0.22 g/g during the fifth week of storage. Although the same trend was observed for both defatted and undefatted samples, the values for the defatted samples were significantly ($P = 0.05$) higher than the undefatted samples throughout the storage period. This was probably due to the fact that the defatted samples contained lesser fat (45% against 65%) than undefatted sample. Hence, the defatted sample had greater capacity to absorb fat. The decrease in FAC in the samples after the third week of storage could be due to alteration in the protein-polysaccharide complex. This observation tallies with the report of Nwosu *et al.* (2005).

Data obtained for water absorption capacity (WAC) of defatted sample increased from 7.02 ± 1.81 g/g during the first

week of storage to a maximum of 9.81 ± 0.21 g/g during third week (Table 3). Afterwards, the value decreased to 6.53 ± 1.22 g/g at the fifth week of storage. Undefatted *ogbono* flour followed similar trend with gradual increase from 6.20 ± 1.91 g/g to a maximum value of 8.41 ± 2.21 g/g, and then decreased to 3.33 ± 0.99 g/g during the fifth week of storage. Despite the fact that the same trend was observed, the values for defatted sample were significantly ($P=0.05$) higher than undefatted samples throughout the storage period. This could probably be due to the fact that the defatted samples (giving its lower fat content) had higher affinity for water as against undefatted sample, which had lower affinity. The removal of some fat from the flour might have enhanced protein's ability to associate with water, i.e., form hydrogen bond with water and water-soluble species. This implies that the defatted sample had greater capacity to absorb water as earlier reported by Onweluzo *et al.* (1995). The appreciable high WAC of *ogbono* flour could be utilized in food formulations (for novelty foods). The "rise and fall" syndrome as observed in the WAC and FAC of *ogbono* flour was equally reported by Nwosu *et al.* (2005), who attributed it to a reduction in protein quality during storage.

TABLE 3: FUNCTIONAL PROPERTIES OF OGBONO FLOUR AS AFFECTED BY DEFATTING AND PERIOD OF STORAGE.

WEEK	DEFATTED			UNDEFATTED		
	FAC (g/g)	WAC (g/g)	FFA (g/100g)	FAC (g/g)	WAC (g/g)	FFA (g/100g)
1	1.73 ± 0.29	7.02 ± 1.81	3.31 ± 0.02	1.15 ± 0.38	6.20 ± 1.91	4.03 ± 0.04
2	1.87 ± 0.24	8.02 ± 1.45	3.60 ± 0.02	1.34 ± 0.19	7.68 ± 1.76	4.17 ± 0.02
3	1.98 ± 0.32	9.81 ± 0.21	6.04 ± 0.05	1.61 ± 0.25	8.41 ± 2.21	7.34 ± 0.06
4	1.48 ± 0.29	6.08 ± 0.68	7.77 ± 0.05	0.83 ± 0.23	3.98 ± 0.92	9.93 ± 0.11
5	1.03 ± 0.52	6.53 ± 1.22	10.07 ± 0.02	0.27 ± 0.22	3.33 ± 0.99	16.84 ± 0.34
MEAN	1.62 ± 0.48	7.49 ± 1.77	6.16 ± 0.22	1.04 ± 0.52	5.92 ± 2.55	8.46 ± 0.36
LSD	0.11	0.20	0.03	0.11	0.20	0.03

FAC= Fat absorption capacity; WAC= Water absorption capacity; FFA= Free fatty acid

The free fatty acid (FFA) values obtained for defatted and undefatted samples are shown in Table 3. Free fatty acids increased in all the samples during storage. FFA for defatted sample gradually increased from 3.38 ± 0.02 g/100g during the first week of storage to 10.07 ± 0.02 g/100g in the fifth week. The undefatted *ogbono* flour followed similar trend with gradual increase from 4.03 ± 0.04 g/100g during the first week of storage to 16.84 ± 0.34 g/100g during the fifth week. Although similar trend was observed, the FFA values for the defatted sample were continuously lower ($P=0.05$) than those for the undefatted samples. The mean FFA for undefatted samples was 8.46 ± 0.36 g/100g against 6.16 ± 0.22 g/100g for the defatted samples. The FFA obtained for undefatted samples were higher than 5 g/100g, which is the recommended critical value of FFA for optimum health condition (NIS, 1992). Although the FFA obtained were not outrageously high, but unfortunately they are saturated fatty acids as reported by (Eka, 1980). *Ogbono* has about 65% fat and nearly all are saturated fatty acids (Ihediohanna and Ijioma, 2005).

INTERACTION OF DEFATTING, CHEMICAL TREATMENT AND PERIOD OF STORAGE ON FUNCTIONAL PROPERTIES OF OGBONO FLOUR.

Fat absorption and water absorption capacities of *ogbono* flour decreased with storage while FFA increased (Table 3). On the average, the chemical treatments reduced FAC of the samples (Fig 1.a), but unlike the control, which had a sharp fall in FAC, the chemically treated samples had a

gradual loss of their FAC during storage. It was further observed that sample with mixed chemical treatment which had the lowest FAC on the first week turned around to had the lowest at the final week of storage. This result is suggesting that mold inhibitor and/or anticaking agent could be used to preserve *ogbono* flour without fear of losing FAC. In the case of water absorption capacity (WAC), the untreated sample had the lowest absorption capacity among all the samples throughout the period of the experiment. One gram of the flour absorbed 5.02 ± 0.21 g of water during the first week of storage and increased to 7.18 ± 0.12 g during the third week of storage and then gradually reduced to 4.72 ± 0.31 g during the fifth week of storage. The samples with either mold inhibitor or anticaking agent followed the same trend, though that with anticaking agent maintained higher values than that treated with mold inhibitor. The variation observed could probably be as a result of the some chemical reactions. For instance ammonium bicarbonate being hygroscopic, might have increased water absorption capacity of the flours. In all the samples WAC reduced after the third week of storage and remained somewhat constant after the fourth week. Nwosu *et al.* (2005) who obtained similar result suggested that the reason could be because of protein-polysaccharide interaction caused by grinding operation. Hence, mold inhibitor and anticaking agents could be incorporated into *ogbono* flour to enhance its utilization in homes and industries

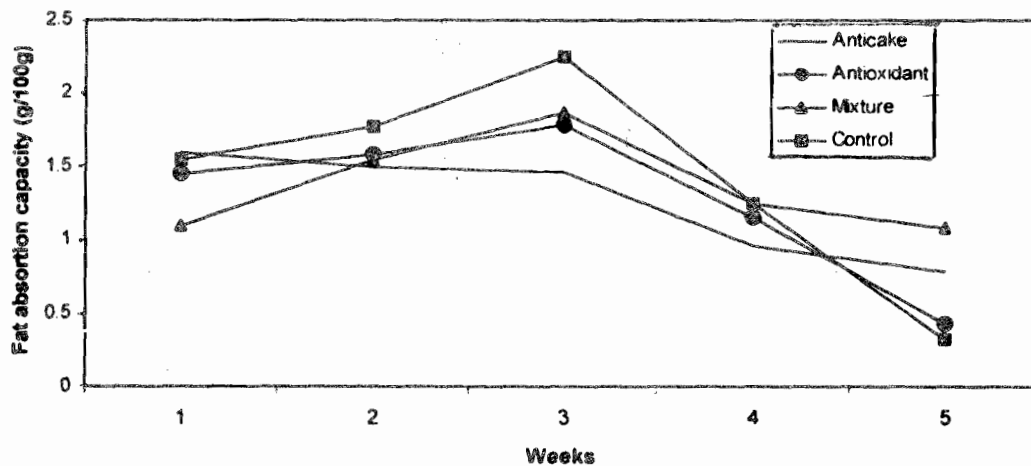


Fig 1a. Fat absorption capacity of ogbono flour as affected by chemical treatment and storage (ambient)

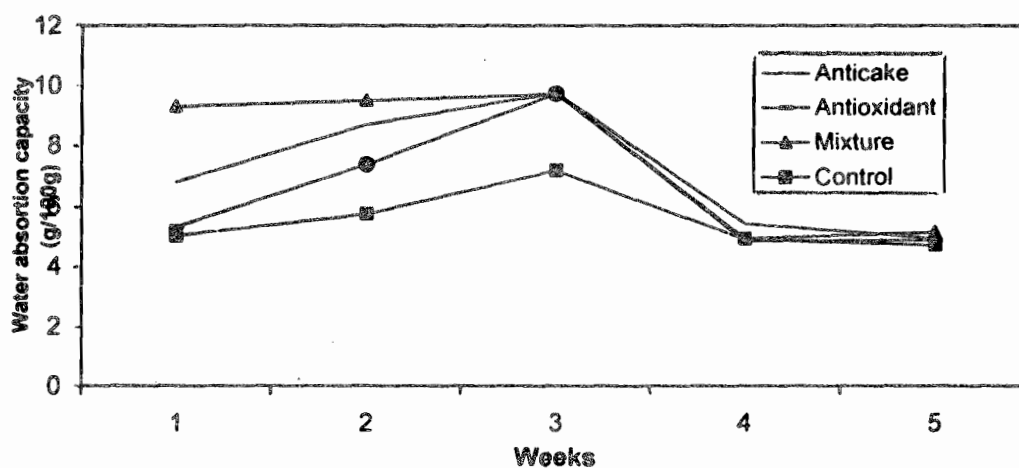


Fig 1b. Water absorption capacity of ogbono flour as affected by chemical treatment and storage (ambient)

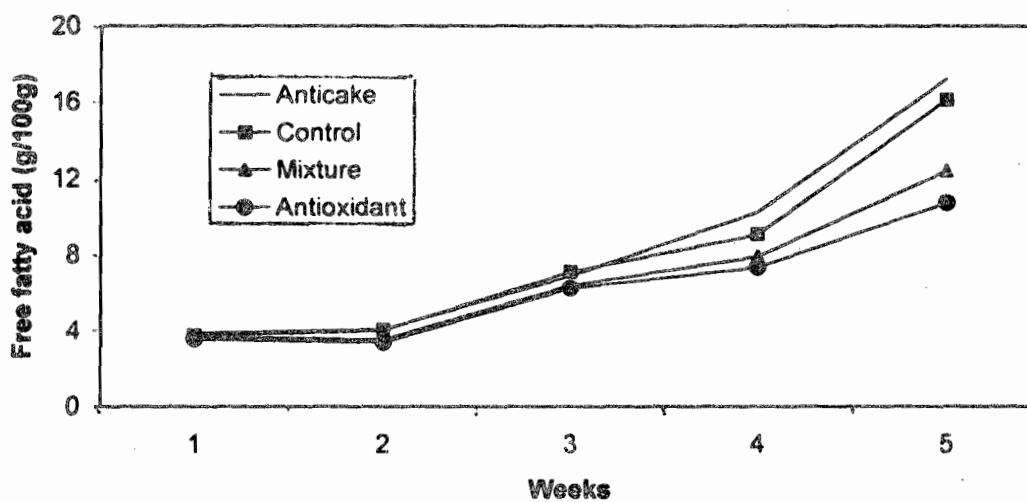


Fig 1c. Development of free fatty acid on ogbono flour samples during storage at ambient temperature

There was a steady significant ($P=0.05$) increase of free fatty acid (FFA) in all the samples during storage (Fig 1c.). After the second week of storage, free fatty acid started developing more on the control sample and that treated with anticaking agent. In the samples with either mold inhibitor alone or in combination with anticaking agent a reduced FFA was observed. But in all, samples with mold inhibitor expectedly had the lowest ($P=0.05$) FFA value at each stage of storage. It could be that the antioxidant expectedly prevented the growth of mold, which initiates rancidity. This suggests that *ogbono* flour could be preserved by the addition of mold inhibitor such as sorbic acid. The effect of the chemicals on FFA was noticed more on defatted samples. So, a combination of defatting process and mold inhibitor treatment could be a viable means towards shelf-life extension of *ogbono* flour.

CONCLUSION

This study has shown that the shelf stability of *ogbono* flour could be improved through partial defatting and chemical treatment. These treatments also enhanced the convenience of use and, possibly, health benefits of this food hydrogel. We want to emphasize that the treatments used in this study are recommendable since they did not reduce the functionality of the *ogbono* flour. Hence, *ogbono* flour could be preserved to enhance availability (food security). It could also be designed for new food product development (novelty food). The extracted fat from the flour having high saponification value (230) as reported by Okolo, (1998) could be suitable for industrial use (soap manufacturing, cosmetics and pharmaceuticals). Preparation of *ogbono* in flour form may help to reduce drudgery of housewives since the flour is a kind of instant soup thickener.

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