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Research Paper

Effect of processing on the proximate composition, functional properties and storage stability of water melon (*Citrullus lanatus*) seed flour

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Abstract. Water melon (*Citrullus lanatus*) seeds were subjected to three different processing methods (sun drying, roasting and boiling/oven-drying). The processed seeds were milled into flour. Chemical composition, functional properties and storage characteristics of sun dried, roasted and boiled/oven-dried flours were investigated. The processed flours were stored for five weeks at room temperature (28 ± 1°C) and moisture content, free fatty acid and peroxide values determined weekly. The result shows that roasting significantly reduced ($P < 0.05$) all the functional properties of the flour, there was a significant difference ($P < 0.05$) between sun dried samples in terms of water and fat absorption, viscosity and least gelatin concentration except for foam capacity. Roasting and boiling/oven-drying decreased the foam capacity; however boiling for 10 minutes then oven dry at 50°C for 12 hours proved to be more effective than sun drying and roasting in improving the functional properties of the water melon seed. Free fatty acid and peroxide values of the flour samples increased slightly during storage but were within the reported acceptable limits.

Keywords: Water melon seeds, functional properties, roasting, sun drying, boiling/oven drying.

INTRODUCTION

Water melon (*Citrullus lanatus)* is an important seed crop grown on a large scale in Northern Nigeria, Asia, America and other temperate climate in Europe. *C. lanatus* is an annual climbing or trailing herb up to 3 m high which belongs to the *cucurbitaceace* family, of grassy savanna and bush savanna (Ng, 1993), occurring as an introduced cultivated plant throughout the West African region (Sodeke, 2005). They naturally have seeds although there are new cultivars that are seedless.

The consumption of water melon in Nigeria has increased tremendously in recent years probably due to the increased awareness on the health benefits. Water melon is a potent source of a biological active compound known as caroteniods. Caroteniods such as β-carotene, α -carotene and lycopene fight and neutralize free radicals in the body. Free radicals oxidize cholesterol in the body and make it to stick to the walls of the blood vessels that can lead to heart attack. Several studies have shown that high intake of these anti-oxidants (carotenoids) found in water melon fruits, tomatoes and other fruits reduces the risk of cancer, arthritis (Seddon et al., 2014; Oseni and Okoye, 2013). Apart from its low energy value, the fruits water melon is known for their high micronutrients concentration such as vitamin K, ascorbic acid, riboflavin, iron and other minerals (Johnson et al., 2012).

Water melon seeds are high in proteins and fat and can find application as a protein source in various food formulations and preparations (El-Adway and Taha, 2001). Water melon seeds are among the under utilized fruit by-products, though technology exist for decorticating the seeds, only a small proportion of the seed is commercially processed while the remaining is discarded (Lakshimi and Kaul, 2011).

In Nigeria, the consumption of water melon is limited to the fresh fruits either as desert or as fruit salads with paw-paw, pineapple and other fruits, the seeds are discarded. However, the seed is about 1 to 4% while the pulp and the rind is 70 and 26%, respectively.

Protein and fat together account for ¾ of the weight of the seeds and is grouped as oilseeds. It is used as a condiment, garnisher, thickener in soups, fat binder, flavourant, as snack in some parts of the world, its flour is added to wheat flour for production of bread in some countries (El-Adway and Taha, 2001).

Traditionally, the seeds are removed from the rind and then allowed to dry outside in the sun, once dried, the seeds are then milled into flour. Many plant proteins usually in the form of protein extracts or seeds flour are being investigated and tested for new novel food products such as low cost fabricated foods which are nutritious, attractive and acceptable to consumers (McWalters et al., 1976).

The ultimate success of utilizing plant proteins as ingredient largely depends upon the beneficial qualities they impact to foods which in turn depend largely on their nutritional and functional properties.

Improvement in the utilization of water melon seeds can be achieved if we understand the functional behavior of the seed flour in the food system. This study therefore is aimed at evaluating the effects of processing on the chemical composition and functional properties of the water melon seed flour as well as the storage stability of the processed seed flour.

MATERIALS AND METHODS

Materials

Water melon fruits weighing between 10 and 15 kg were purchased from a local market in Port Harcourt, Nigeria. All chemicals used for this study were of analytical grade.

Preparation of water melon seed flour

Water melon seeds were obtained from the pods and rinds and washed. The seeds were divided into three equal parts each weighing 4 kg. One part was subjected to sun drying at 32 ± 2°C for three days, the second part was roasted in the oven at 160°C for 30 min while the third part was boiled for 10 min and oven dried at 50°C for twelve hours.

The sun dried, roasted and boiled/oven dried seeds were dehaulled, dry-milled into flour (0.70 mm) as shown in Figure 1. Each processed flour was further divided into three parts; one part used for proximate analysis, second part for functional properties and third part was used for storage studies.

Storage stability

One hundred gram (100 g) of flours from the sun dried, roasted and boiled/oven-dried seeds were put into polyethylene bags (0.04 mm thick), separately. The bags were sealed using a vacuum sealer (Salton, UK) and stored at room temperature (28 ± 1°C) for five weeks. Sample bags from each processing method were removed at the end of every week during storage period and analysed for moisture, free fatty acid content, and peroxide value.

Chemical analysis

Moisture (method 14.004), total ash (method 14.006), crude fiber (method 7.070), either extract (method 7.062) and crude protein (method 2.057) were determined according to AOAC (2006) procedures. The factor N x 6.25 was used for conversion of nitrogen to crude protein. Carbohydrate content was calculated by difference.

Free fatty acid (FFA) content and peroxide value (PV) were determined using the methods described by Egan et al. (1981). FFA was expressed as % linoleic acid while PV was expressed as miliequivalent equivalents of peroxide per kg of sample (mEq/kg).

Functional properties

Water melon seed flour samples for selected functional properties was defatted using solvent extraction apparatus (Techator Inc. Colorado, U.S.A) for eight hours refluxing with n–hexane. Water and oil absorption capacities of the samples were determined according to the procedure outlined by Beuchat (1977) as modified by Giami et al. (1994). The least gelation concentration and viscosity were determined according to the methods of Coffman and Garcia (1977) and Fleming et al. (1975), respectively.

Statistical analysis

All experiments were carried out in triplicates and the mean calculated. Data were subjected to analysis of variance (ANOVA) using a one way model reported by Wahwua (1999). Duncan multiple range test was used to separate the means where significant differences exit.

RESULTS AND DISCUSSION

The proximate composition of flour obtained from the three processing methods are presented in Table 1. Flour from roasted seeds had a moisture content of 6.30%, which was significantly lower than sun dried (8.59%) and boiled/oven-dried (8.47%) seeds.

The crude protein of the flours ranged from 24.46% in roasted seed flour to 29.25% in boiled/oven-dried seed

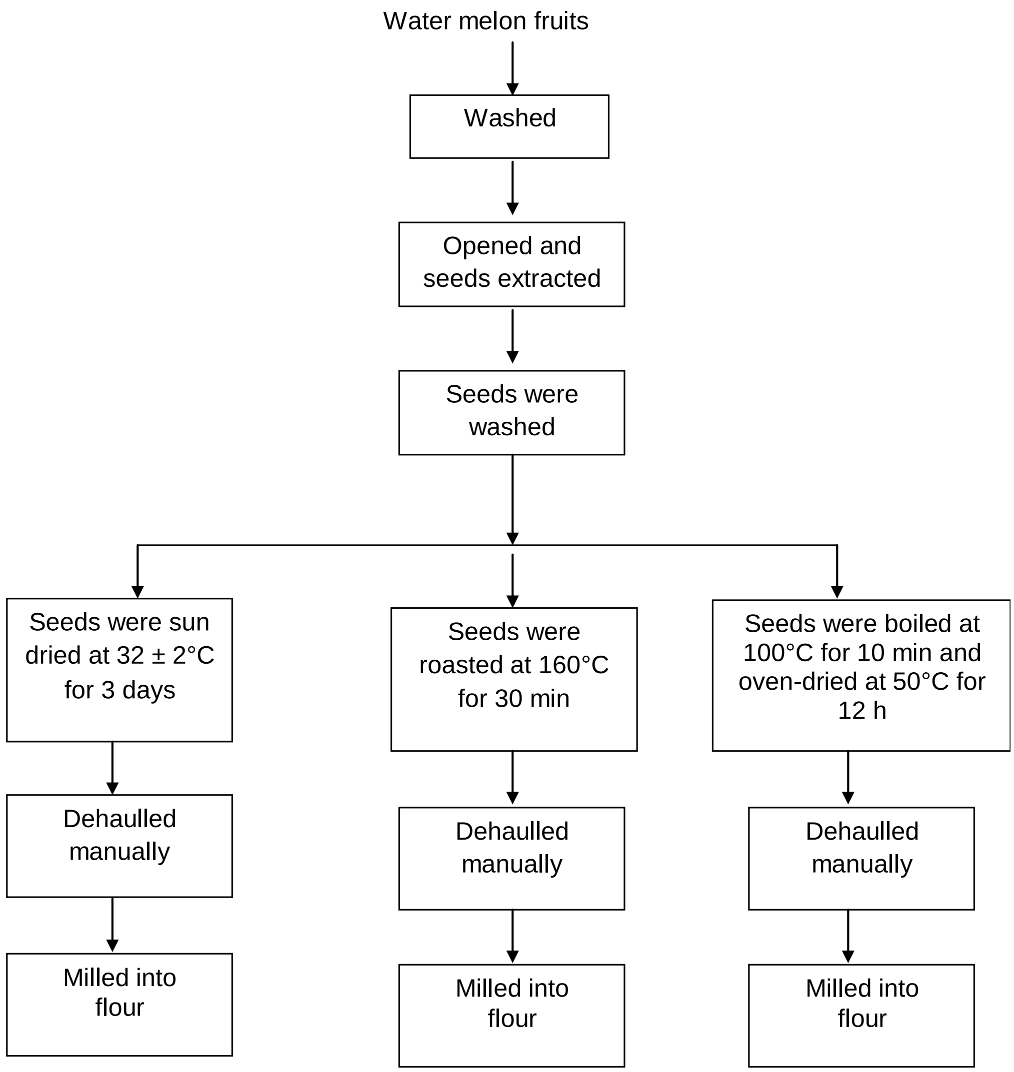

Figure 1. Flow chart for processing methods for water melon seed flour.

Table 1. Proximate composition of flour from sun-dried and heat processed water melon seed flour.

Parameters (%)	Samples		
	Sundried	**Roasted**	**Boiled/oven-dried**
Moisture	8.59 ± 0.4^a	6.30 ± 0.26^b	8.47 ± 0.6^a
Crude protein (N × 6.25)	25.33 ± 0.7^b	24.46 ± 0.46^b	29.25 ± 0.8^a
Ether extract	47.85 ± 0.5^a	45.01 ± 0.3^b	47.22 ± 0.1^a
Total ash	4.20 ± 0.09^a	3.91 ± 0.7^a	4.01 ± 0.3^a
Crude fibre	3.85 ± 0.8^a	2.86 ± 0.4^b	3.57 ± 0.5^a
Carbohydrates	8.18 ± 0.1^a	7.46 ± 0.5^a	7.48 ± 0.2^a

Values are mean of triplicate determinations ± standard deviation. Means within a row with different letters are significantly different (P > 0.05).

flour. It shows that boiling increased significantly the crude protein of water melon seed flour. This suggests that the water melon seed flour may be useful as a protein supplement in the diet of malnourished people. This observation is similar to the report of Giami et al. (2000) who observed that boiling improved protein digestibility of African breadfruit seeds than roasting. Ether extract ranged from 45.01% (roasted) to 47.85%

Table 2. Functional properties of water melon seed flour from three processing methods (sun dried, roasted, boiled and oven-dried).

Samples	Functional properties				
	Water absorption capacity (g/g)	Oil absorption capacity (g/g)	Foam capacity (ml)	Viscosity (Pa.S)	Least gelation (%)
Sun dried	94.07 ± 0.6^{c}	3.52 ± 0.5^{a}	14.95 ± 0.6^{a}	0.75 ± 0.1^{b}	10.12 ± 0.4^{b}
Roasted	116.07 ± 0.1^{b}	3.56 ± 0.2^{a}	10.34 ± 0.8^{b}	0.461 ± 0.3^{c}	14.03 ± 0.7^{a}
Boiled/oven-dried	124.24 ± 0.8^{a}	4.25 ± 0.4^{a}	13.86 ± 0.7^{a}	0.98 ± 0.5^{a}	8.032 ± 0.8^{c}

Values with the same superscript within the same column do not differ significantly (P > 0.05). Mean values ± standard deviation of triplicate determinations.

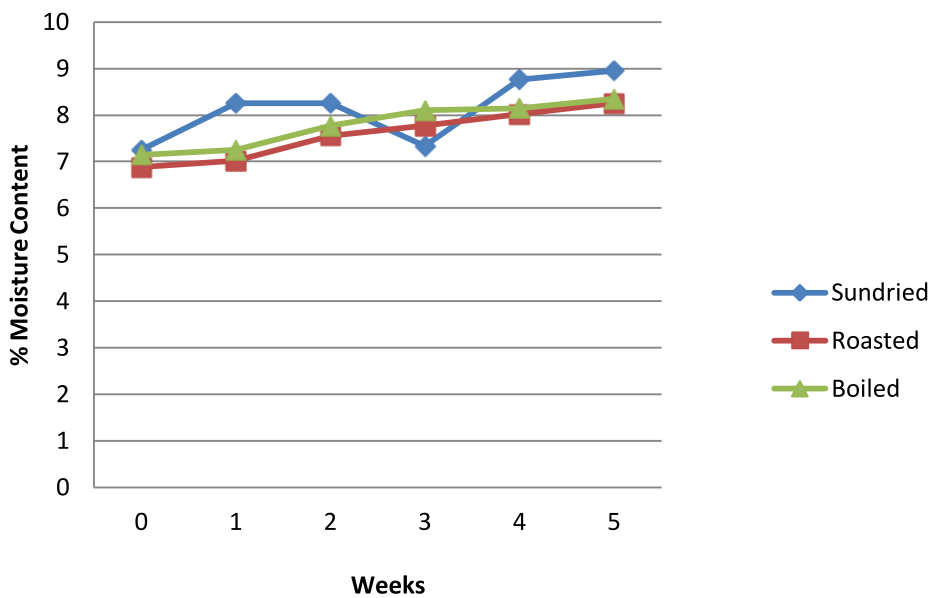

Figure 2. Effect of storage on the moisture content of processed water melon seed flour.

observed in sun-dried sample. However, there was no significant difference (P > 0.05) between sun dried and boiled/oven dried samples. The result obtained were in agreement with the work of Oyeleke et al. (2012) who reported 27.4% crude protein, 47.9% fat and 9.9% carbohydrates for water melon seeds. These values are within the range of other oilseeds as reported by Penuel et al. (2012). Roasting reduced the oil content of the flour; this may probably due to volatilization or melting out of the fat as earlier observed by Igbedioh et al. (1994). However, roasting as a processing method may be useful where less fat and long storage stability are required.

Table 2 shows the effect of processing methods on selected functional properties of water melon seed flour. Roasting and boiling improved the water and fat absorption capacities compared to the sun dried samples. This may be due to the effect of heat on the fat/oil structure within the water melon seeds. Giami et al. (1993) and Giami and Wachuku (1997) reported similar trend in legumes and oil seeds samples used as soup condiment in Nigeria.

Roasting has also shown to significantly (P < 0.05) lower the foaming capacity, viscosity and least gelation concentration of water melon seed flour compared to the sun dried and boiled/oven-dried samples. It should be noted that water absorption capacity, viscosity and least gelation concentration are all important functional properties of legume/oilseeds which could be useful in egusi-like soup preparations.

Thus, the results obtained in this study suggest that boiling/oven-dried samples may be a better processing method compared to roasting and sun-drying.

The effects of storage (room temperature) on the moisture content of the processed water melon seed flour is presented in Figure 2. The moisture content of all the treatment methods was observed to increase gradually with storage. The highest moisture content of 8.96% was observed in sun-dried flour at the 5th week of storage. However, this was not significantly different (P ≤ 0.05) from roasted and boiled/oven seed samples at the same period. The initial free fatty acid value of the seed oil extracted from the flour is 0.25% in roasted sample which was significantly lower compared to 0.33 and 0.35% obtain in boiled/oven dried and sun-dried methods,

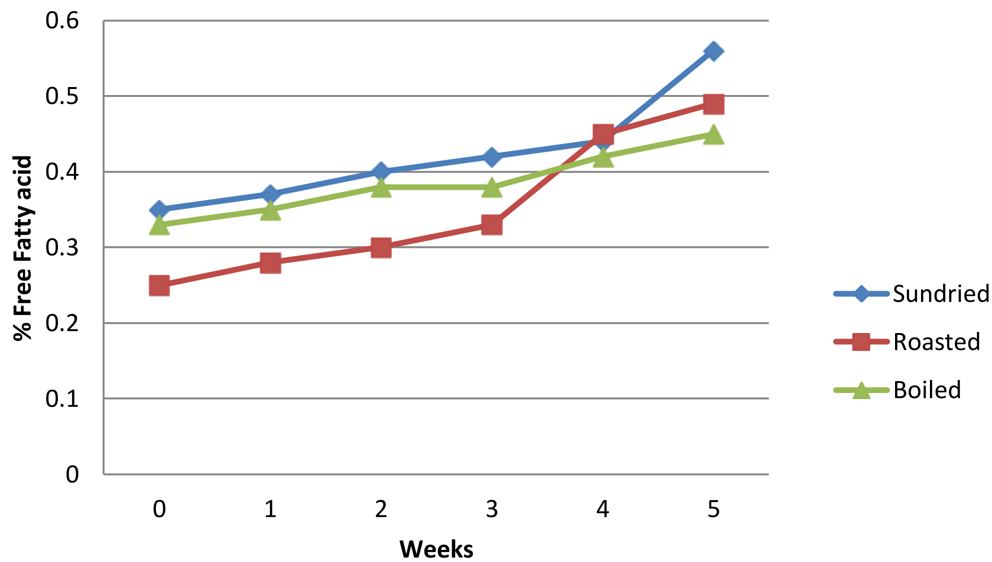

Figure 3. Effect of storage on the free fatty acid of processed water melon seed flour.

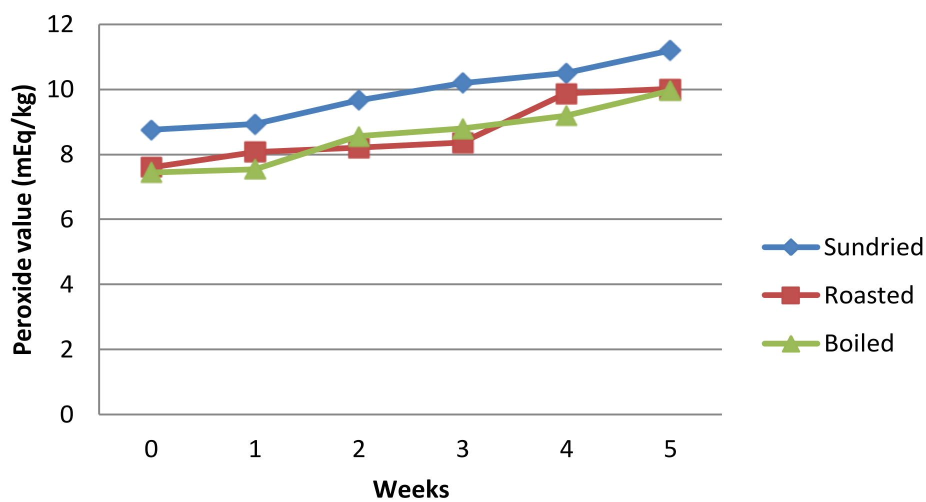

Figure 4. Effect of storage on the peroxide value of processed water melon seed flour.

respectively, as shown in Figure 3. There was no significantly increase in the free fatty acid of the flours from the three processing methods employed in this study. The results ranged from 0.35 to 0.56% in sun-dried, 0.25 to 49% for roasted and 0.33 to 0.45% free fatty acid in boiled/oven-dried. These values are lower than 0.5 to 1.5% FFA prescribed for good quality oils by Egan et al. (1981) and 1.5% free fatty reported by Adewuyi et al., (2013). However, the slight increase observed may be due to lipid hydrolysis during the storage periods. This observation is in agreement with the report of Giami et al. (2000) for fluted pumpkin seed oils.

The effect of storage on the peroxide value of water melon seed flour processed is presented in Figure 4. Maximum values of 11.20, 10.01 and 9.9 mEq/kg were observed in sun dried, roasted and boiled/oven water melon seed flours, respectively stored for 5 weeks. These values are low compared to 18.75% reported for sun dried water melon seed by Taiwo et al. (2008), 2.98 mmol/g for water melon seed oil and 19.54 mmol/g for melon seed oil reported by Ebuehi and Avwobobe (2006).

Conclusion

The results of this study have shown that boiling/oven-drying was a better processing method compared to roasting and sun-drying in terms of proximate composition and functional properties. There was no adverse increase in moisture content, free fatty acid and peroxide value of flours stored for 5 weeks using the three processing methods.

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