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Comparative Investigation of the Proximate and Functional Properties of Watermelon (*Citrullus lanatus*) Rind and Seed

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ABSTRACT

The proximate and functional properties of the watermelon (*Citrullus lanatus*) rind and seed flour were investigated, using standard methods. The proximate compositions (%) for the rind and seed, respectively were moisture (5.12 ± 0.01 , 3.81 ± 0.00), dry matter (94.88 ± 0.01 , 96.20 ± 0.00), lipid/fat (1.05 ± 0.01 , 41.84 ± 0.04), crude protein (7.04 ± 0.00 , 21.46 ± 0.04), carbohydrate (80.75 ± 0.04 , 28.05 ± 0.06), crude ash (3.07 ± 0.00 , 2.48 ± 0.01) and crude fibre (2.98 ± 0.00 , 2.37 ± 0.00). The energy value (360.59 ± 0.01 , 574.58 ± 0.30 kcal), total sugar (0.47 ± 0.01 , $3.23 \pm 0.02\%$) and total soluble sugar (1.42 ± 0.01 , $4.87 \pm 0.00\%$), respectively for the rind and seed were lower in the rind than in the seed sample. The functional properties (%) for the rind and seed, respectively viz. water absorption capacity (7.13 ± 0.00 , 116.3 ± 0.00), oil absorption capacity (1.65 ± 0.00 , 123.5 ± 0.00), foaming capacity (5.65 ± 0.00 , 21.5 ± 0.00), foaming stability (20.75 ± 0.00 , 60.5 ± 0.00) and emulsion stability (0.28 ± 0.00) were higher in the seed sample. The difference in value of the parameters for the samples, aside emulsion stability, ash and fibre, were significant ($p < 0.05$). The results imply that the flour of watermelon (*Citrullus lanatus*) seed, followed by that of the rind, has nutrient, energy, storage and industrial potentials which could increase their utilization thereby preventing a possible adverse environmental effect.

Key words: Nutrient, energy value, oil absorption capacity, environment, food waste

INTRODUCTION

Generally, fruits are natural source of various bioactive phytochemicals that are associated with their medicinal value (Edeoga *et al.*, 2005). This fact tends to increase fruit production and consumption the world over, with the attendant increase in fruit wastes. For instance, watermelon, which belongs to the family Cucurbitaceae and specie *Citrullus lanatus*, is a major fruit widely distributed in the tropics (Yamaguchi, 2006). The fruit serves as a thirst-quencher owing to its high (92%) water content (Ensminger and Ensminger, 1986). It is an excellent source of minerals (Hall, 2004), lycopene, vitamins C and A (Edwards *et al.*, 2003). However, the juice or pulp of the watermelon is consumed whereas the rind and seed are mainly discarded as agricultural food wastes which constitute solid waste to the environment.

To prevent solid waste related hazards to the environment, effort should be made to increase the utilization of food wastes. Therefore, studies on the properties of agricultural food waste are required to provide scientific basis for their possible potential use, including in diets, drugs and industries. Studies on watermelon fruits were reported, but mainly on the juice/pulp (Johnson *et al.*, 2012; Oseni and Okoye, 2013) and a little on the peel/rind (Fila *et al.*, 2013; Gin *et al.*, 2014). These warranted the present study aimed at investigating the proximate and functional properties of the watermelon (*Citrullus lanatus*) rind and seed flours.

MATERIALS AND METHODS

Collection and preparation of samples: Watermelon fruits were bought from Onuimo market, in Imo State border/boundary with Abia State, Nigeria. It was identified as Charleston gray variety in the Department of Plant Science and Biotechnology, Michael Okpara University of Agriculture Umudike, Nigeria. The watermelon was thoroughly washed to remove sand particles after which it was sliced using a home choice European knife. The seeds were handpicked and washed off the pulp particles using clean water. The pulp was carefully scraped off to obtain the rind which was chopped into pieces with a chipping machine.

The rind and seed chips were, respectively weighed, using Satorious Digital Weighing Balance, Model BP210S, Germany. The rind (wet weight = 1900.7 g) and seed (wet weight = 1016.9 g) were separately spread on a foil and sundried for three days to obtain the corresponding dry weight for the rind (82.6 g) and seed (468.5 g). The respective dry weight samples were milled into powder using Arthur Thomas Laboratory Mill, Crypto model, USA, covered separately in a labeled white nylon before and kept in the desiccators prior to use.

Chemicals and reagents: All chemicals used, including those used in the preparation of reagents, were of analytical grade and products of reputable companies.

Determination of the proximate and functional properties: The proximate composition viz., moisture, ash, protein, fibre, fat/lipid, dry matter and carbohydrate as well as the energy value were determined and calculated using the AOAC (1990) methods.

Functional properties viz. Water Absorption Capacity (WAC) and Oil Absorption Capacity (OAC) were determined by the methods of Okaka and Potter (1979). The emulsion capacity was determined by blending 2 g of the sample in 25 mL of distilled water, using Warring blender at 1600 rpm for 30 sec. After complete dispersion 25 mL of vegetable oil was gradually added and the blending continued for another 30 sec. The resultant mixture was transferred into a centrifuge tube and centrifuged at 1600 rpm for 5 min. Volume of oil separated from the sample after centrifuge was read directly from the tube and the emulsion capacity calculated from the relation:

$$EC = \frac{X}{Y} \times 100$$

where, X is the height of emulsified layer and Y is the height of whole solution, in the centrifuge tube.

The foam capacity was calculated, after blending 2 g dry weight of the sample suspended in 100 mL of distilled water, using a Warring blender whipped at 160 rpm for 5 min and recording the volume of the resultant mixture (after 30 sec the mixture was poured into a 250 mL measuring cylinder), from the relation:

$$\text{Forming capacity} = \frac{\text{Volume after whipping} - \text{Volume before whipping}}{\text{Volume before whipping}} \times 100$$

Foam stability was calculated, after recording the foam volumes obtained, as described above, at five different time intervals (5, 15, 30, 60 and 120 min), from the relation:

$$\text{Foaming stability} = \frac{\text{Foam volume after time 't'}}{\text{Initial foam volume}} \times 100$$

Total sugar was determined by dissolving 1 g of sample in 100 mL of distilled water and centrifuging for 10 min at 3000 rpm. Then, 5 µL of the extract was mixed with 500 µL of 4% phenol, 2.5 mL of 96% sulphuric acid and 1 mL of distilled water. The absorbance at 490 nm was read against a blank, using a spectrophotometer (Jenway Digital Spectrophotometer, Model 6320D, France) and the value calculated from a standard curve equation.

Total soluble sugar was determined according to the anthrone colorimetric method described in Luo and Huang (2011) thus: The sample (0.1 g) was weighed in a 10 mL centrifuge tube, to which 6-7 mL of 80% ethanol was added. The sample was heated in an 80°C water bath for 30 min, then centrifuged (3000 rpm) for 5 min. The supernatant was collected and the extraction was repeated twice (3000 rpm for 10 min each). The supernatant was collected into a flask and 80% ethanol was added to total volume of 50 mL. Then, 1 mL of solution was taken and 1.5 mL of water was added, followed by 6.5 mL of anthrone reagent. The sample was mixed and incubated at room temperature (18-30°C) for 15 min to allow color developing. The absorbency at 620 nm wavelength was measured after the sample was cooled down. The total soluble sugar was calculated from the relation:

$$\text{Content of total soluble sugar (\%)} = \frac{C \times (V/a)}{W \times 106} \times 100$$

Where:

C = Glucose content obtained by referring to the standard curve (µg)

V = Total volume of the extracted solution (mL)

a = Volume of sample solution for color developing (mL)

W = Weight of sample (g)

Data analysis: Data were analyzed for statistical significance by one-way analysis of variance, using the Students 't' test for the comparison of means. Difference in the mean values (n = 2 obtained from duplicate test of each sample) at p<0.05 were regarded as significant. All data were expressed as Mean±SD (Standard deviation).

RESULTS

As shown in Table 1, the proximate compositions in percentage (%) for the rind and seed, respectively were moisture (5.12±0.01, 3.81±0.00), dry matter (94.88±0.01, 96.20±0.00), lipid/fat

Table 1: Proximate composition of watermelon (*Citrullus lanatus*) rind and seed flour

Parameters	Rind (%)	Seed (%)	Difference (%)
Moisture content	5.12±0.01	3.81±0.00	±1.31*
Dry matter	94.88±0.01	96.20±0.00	±1.32*
Ash	3.07±0.00	2.48±0.01	±0.59 ^{ns}
Lipid/fat	1.05±0.01	41.84±0.04	±40.79*
Crude fibre	2.98±0.00	2.37±0.00	±0.61 ^{ns}
Crude protein	7.04±0.00	21.46±0.04	±14.42*
Carbohydrate	80.75±0.04	28.05±0.06	±52.70*

Result = Value±SD of duplicate determinations, ns: Difference is not significant (p>0.05), *Difference is significant (p<0.05)

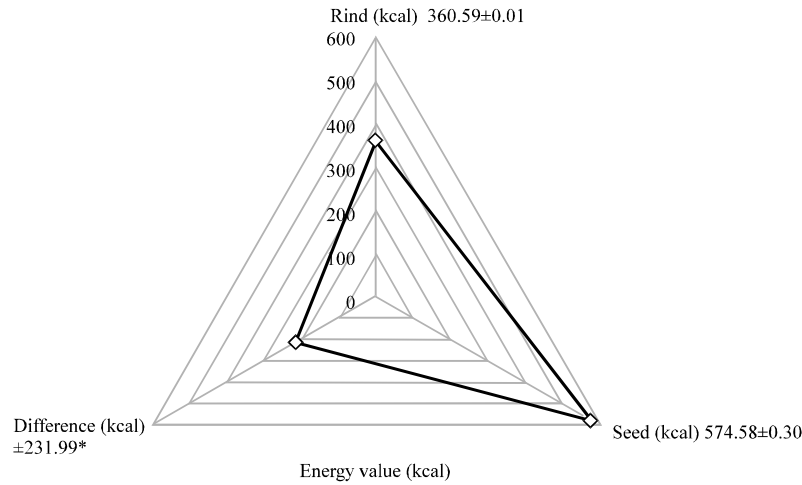


Fig. 1: Energy value (kcal) of the watermelon (*Citrullus lanatus*) rind and seed, Result = Value±SD of duplicate determinations. *Difference is significant (p<0.05)

Table 2: Functional properties of the watermelon (*Citrullus lanatus*) rind and seed flour

Parameters	Rind (%)	Seed (%)	Difference
WAC	7.13±00	116.30±00	±109.17*
OAC	1.65±00	123.50±00	±121.65*
FC	5.65±00	21.50±00	±15.85*
FS	20.75±00	60.50±00	±39.75*
ES	-	0.28±00	±0.28 ^{ns}

Result = Value±SD of duplicate determinations, ns: Difference is not significant (p>0.05), *Difference is significant (p<0.05), WAC: Water absorption capacity, OAC: Oil absorption capacity, FC: Foaming capacity, FS: Foaming stability, ES: Emulsion stability

(1.05±0.01, 41.84±0.04), crude protein (7.04±0.00, 21.46±0.04), carbohydrate (80.75±0.04, 28.05±0.06), crude ash (3.07±0.00, 2.48±0.01) and crude fibre (2.98±0.00, 2.37±0.00). The difference in value of the proximate parameters for the samples, aside crude ash and fibre, were significant (p<0.05).

The energy value (360.59±0.01, 574.58±0.30 kcal) (Fig. 1), total sugar (0.47±0.01, 3.23±0.02%) (Fig. 2) and total soluble sugar (1.42±0.01, 4.87±0.00%) (Fig. 3), respectively for the rind and seed were lower in the rind than in the seed sample.

The functional properties (Table 2) in percentage (%) for the rind and seed, respectively viz. Water absorption capacity (7.13±00, 116.3±00), oil absorption capacity (1.65±00, 123.5±00), foaming capacity (5.65±00, 21.5±00), foaming stability (20.75±00, 60.5±00) and emulsion stability (0.28±00) were higher in the seed than in the rind sample. The difference in value of the functional parameters for the samples, aside emulsion stability were significant (p<0.05).

DISCUSSION

Usually, the watermelon (*Citrullus lanatus*) rind and seed are discarded as agricultural food wastes. The present study investigated the proximate and functional properties of the Charleston gray variety of watermelon (*Citrullus lanatus*) rind and seed flour to obtain a scientific basis for their possible use in diets, drugs and industries. The proximate compositions in percentage for the rind and seed shown in Table 1. The difference in value of the proximate parameters for the

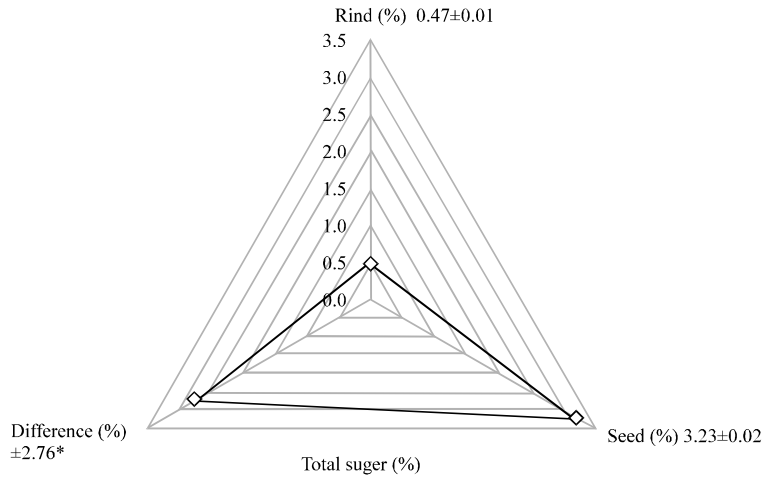


Fig. 2: Total sugar (%) of the watermelon (*Citrullus lanatus*) rind and seed, Result = Value±SD of duplicate determinations. *Difference is significant ($p < 0.05$)

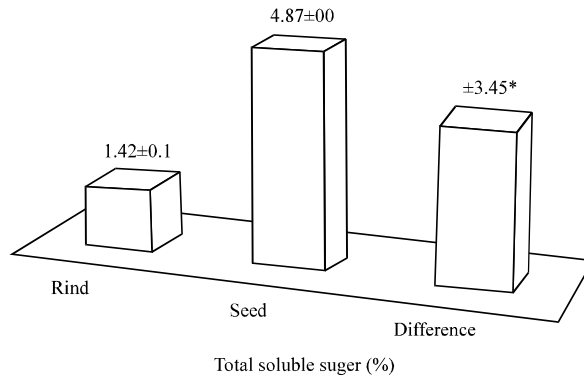


Fig. 3: Total soluble sugar (%) of the watermelon (*Citrullus lanatus*) rind and seed, Result = Value±SD of duplicate determinations. *Difference is significant ($p < 0.05$)

samples, aside crude ash ($\pm 0.59\%$) and fibre ($\pm 0.61\%$), were significant ($p < 0.05$), suggesting that any difference in the crude ash and fibre contents of the samples is negligible.

Fibre contents of the rind and seed flours compare with the value ($1.90 \pm 0.08\%$) reported by Fila *et al.* (2013). Fibre enhances the proper digestive function thereby preventing constipation and hemorrhoids (Erhirhie and Ekene, 2013). The ash contents of the rind and seed (Table 1) are lower than that of jack bean ($6.51 \pm 0.28\%$) reported by Olalekan and Bosede (2010), suggesting lower mineral contents in the rind and seed flour of the watermelon.

Generally, dry matter content indicates the presence of and quantity of nutrients in a food sample. The dry matter content of the samples is high with that of the seed ($96.20 \pm 0.01\%$) higher ($p < 0.05$) than that of the rind ($94.88 \pm 0.01\%$). This implies more/higher nutrients in the seed sample. The moisture content of either the rind or the seed flour is lower than that of the processed and unprocessed *Dioscorea dumetorum* (Egbonu *et al.*, 2014a). In particular, the moisture content of the rind flour ($5.12 \pm 0.01\%$) agrees with the value ($5.08 \pm 0.02\%$) reported by Fila *et al.* (2013)

whereas that of the seed flour (Table 1) is lower than that reported by Ogunlade *et al.* (2011) for *Azelia africana* (9.49±0.01%) and *Pachira glabra* (9.13±0.02%) and that of the rind sample in this study. The lower moisture content of the seed sample suggests higher dry matter yield (Bamigboye *et al.*, 2010) seemingly supported by its higher dry matter value recorded in this study (Table 1). The lower moisture could enhance storage stability (Ejikeme *et al.*, 2010; Bamigboye *et al.*, 2010; Nzewi and Egbonu, 2011) of the seed flour compared to that of the rind.

The energy values for the samples (Fig. 1) are high, but lower in the rind than in the seed flour. The high energy value of the samples may derive from their carbohydrate, fat and protein contents. The carbohydrate content of the rind is higher while that of the seed is lower than the values for *Pachira glabra* (52.32±0.8%) and *Azelia africana* (45.92±0.72%) reported by Ogunlade *et al.* (2011). The higher energy value of the seed despite the higher carbohydrate content of the rind agrees with the earlier report of Bamigboye *et al.* (2010) attributable to the higher lipid/fat content of the seed recorded in this study. The lipid/fat (1.05±0.01%) and crude protein (7.04±0.00%) contents of the watermelon rind are low in comparison with that of the seed (Table 1). Lipid value of the seed is lower than that of sesame (53.5%) but compares with that of peanut (45.6%) as reported by Aykroyd and Doughty (1982). These suggest that the watermelon seed is an oil seed rich in protein, hence may be utilized as high energy, protein and oil sources.

The total sugar and total soluble sugar are lower in the rind than in the seed flour (Fig. 2 and 3), indicating higher starch (Luo and Huang, 2011) in the rind than in the seed. Soluble sugars, the main photosynthetic product (Bodelan *et al.*, 2010) correlated negatively with the starch content in plant/fruit parts (Luo and Huang, 2011). This agrees with the result in this study of higher carbohydrate content, but lower soluble sugar content, in the rind flour when compared with the seed flour.

The functional properties in percentage (Table 2) reveals that water absorption capacity, oil absorption capacity, foaming capacity, foaming stability and emulsion stability were higher in the seed than in the rind flour. The difference in value of the parameters for the samples, aside emulsion stability is significant ($p < 0.05$). The water absorption capacity of the seed compares with the values reported in Ogunlade *et al.* (2011) and suggests that the seed is less hydrophobic and more viscous than the watermelon rind flour and could be useful in soap production (Ogunlade *et al.*, 2011). The oil absorption capacity of the watermelon seed flour is higher than the value for processed *Dioscorea dumetorum* (Egbonu and Nzewi, 2014; Egbonu *et al.*, 2014b) and *Azelia africana* (Ogunlade *et al.*, 2011), hence could have a better flavor retention and mouth feel potentials. The watermelon rind flour has no emulsion stability as against the 13.19±1.0% reported for jack beans (Olalekan and Bosede, 2010). Generally, emulsion stability is important for stabilization of additives in production of foods like soup and cakes. The watermelon rind and seed flours could not make a good substitute for wheat because of the lack of emulsion stability in the rind flour or a very low emulsion stability in the seed flour compared to the values for *Azelia africana* and *Pachira glabra* (Ogunlade *et al.*, 2011).

The high foaming capacity value of the watermelon seed flour compares with the value (23.5±0.01%) reported by Oyeleke *et al.* (2012), suggesting its importance as an aerating agent in food system (Olalekan and Bosede, 2010). However, the foaming stability of the seed is lower when compared to the value (40%) reported for wheat flour by Akubor and Badifu (2004) which may limit the durability of the resultant foam.

CONCLUSION

The results imply that the flour of watermelon (*Citrullus lanatus*) seed, followed by that of the rind, has nutrient, energy, storage and industrial potentials. Further studies aimed at harnessing the noted potentials are warranted to increase the utilization of the hitherto food wastes and prevent the possible solid waste related hazards to the environment.

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