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ORIGINAL ARTICLE

Effects of Processing Methods on Physicochemical, Functional and Sensory Properties of Two Varieties of Melon Seed *Cucumis mannii* and *Citrullus vulgaris*

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Abstract

Two varieties of Melon (*Cucumis mannii* and *Citrullus vulgaris*) seeds were procured and processed using boiling, parboiling, roasting, fermentation, germination and oven drying methods and milled to flour. Effects of these methods on the physicochemical and functional properties of the obtained flour from each processing method were determined. The flour was further used to prepare "Egusi" soup and the sensory properties of the soup evaluated. The result revealed that the moisture content of the samples ranged from 1.21- 3.86% and it was observed that roasting, fermentation and boiling significantly reduced the moisture contents. Ash content ranged from 1.5-3.09%, with significantly ($p<0.05$) higher ash content noted in roasted C. vulgaris. Roasting and germination gave significantly higher fat content of 59.05% and 58.75%, respectively for *C. mannii*. Protein content of C. vulgaris was shown to increase significantly from 23.27% (raw flour) to 27.79, 27.28, 27.21 and 26.54% for boiled, roasted, germinated and fermented samples, respectively. Crude fibre content of *C. vulgaris* were significantly ($p<0.05$) higher than those of *C. mannii*. Germination was shown to increase crude fibre content in both varieties. Fermented *C. mannii*, fermented C. vulgaris, germinated C. vulgaris and the control (raw C. vulgaris seed flour) gave significantly ($P<0.05$) higher foam capacity of 10.00ml. Processing decreased the bulk density significantly ($P<0.05$) from 0.354- 0.438 g/ml, with the least value recorded in Fermented *C. mannii*. Significantly high water absorption capacity of 1.95g/g was observed in boiled; oven dried and germinated *C. mannii*. Boiling and roasting increased the oil absorption capacity of both varieties of melon seed flours. The raw melon seed fours including germinated *C. mannii*, germinated *C. vulgaris* and fermented C. vulgaris received higher overall acceptability.

Practical application

The knowledge of the effect of processing methods such as boiling, parboiling, roasting, fermentation, germination and oven drying on the physical, chemical, functional and sensory properties of the two varieties of melon seeds can give indication that their processed flours can be used as functional ingredients in food systems such as bakery products, meat substitutes, extenders and their functional behaviour in "egusi" soup preparation. Boiling and roasting increases oil absorption capacity of the processed melon seeds indicating that such seed flours possess a high flavour retention potential which the "egusi" consumers cherish so much.

Keywords: Physicochemical, Sensory, Functional Properties, Processed Melon Seed.

1. Introduction

Melon (*Citrullus vulgaris*) is a delicious fruit packed with nutrition. It is a creeping annual plant belonging to the Curcurbitaceae family with a fibrous and shallow root system. They thrive best in the hot climate regions of Africa and can be grown on rich light soil (Akpambang *et al.*, 2008). Many species of melon are found but they belong to four genera: Momordica, Benin casa, Citrullus and Cucumis (Waluyo, 2015). They have good quantities of sulphur, calcium, potassium, magnesium, phosphorus and manganese. They are necessary in the diet as they have high nutritive and caloric values. Melon seed is a good source of amino acids such as isoleucine and leucine (Olaofe *et al.*, 1994). High content of mineral and protein had also been reported by Ojiel *et al.* (2008) and Akusu & Kiin-Kabari (2015). In addition to a good source of protein, melon seeds are rich in edible vegetable oil varying from 35 to 49% depending on varieties from different regions (De-Mello *et al.*, 2001; Mian-hao & Yansong, 2007; Rashid *et al.*, 2011). Melon seed are known to have therapeutic effect such as antioxidant, anti-inflammatory and analgesic effect in the human body (Chen *et al.*, 2014). It has both nutritional and cosmetic importance and is rich in vitamin C. It can serve as an important supplementary baby food helping to prevent malnutrition. In Nigeria, melon is consumed in various forms such as egusi soup, melon ball snacks and ogiri fermented melon seed (Achi, 2005; Akusu & Chibor, 2019). They are used to prepare food condiment with a characteristic aroma (Akusu & Chibor, 2020). The seed has an increasing demand since they contribute greatly towards achieving a balanced diet (Fokou *et al.*, 2004). The main seed also have high caloric values according to Ojieh *et al.* (2008) such as 45.7% ether extract. The oils from melon seed have been characterized by other researchers (Oresanya *et al.*, 2000; Ebuehi & Avwobobe, 2006) and they observed that melon seed oil contained more of unsaturated fatty acids. They can also be used as flavouring and thickening agents in stews, soup and sauces (Onyeike & Achera, 2002). *Citrullus vulgaris* has been of increasing demand amongst melon species and is cherished and consumed more than other varieties (Akusu & Emelike, 2018). It is becoming very expensive in Nigeria whereas other varieties of melon are highly underutilized as food. Improvement in the utilization of other varieties can be achieved if we understand the proximate composition and functional behaviour of the seed flour in order to determine their suitability in soup preparation. It has been reported that boiling, fermentation and roasting improves the nutritive and functional properties of legumes, (Giami *et al.*, 1999; Achinewhu, 2012). Thus, the need to investigate the effects of those processing methods on different varieties of melon seeds becomes imperative. The objective of this work was then to evaluate the effects of roasting, parboiling, boiling, soaking and fermentation on the physicochemical and functional properties of *Cucumis mannii* and *Citrullus vulgaris* seed flour, as well as the sensory characteristics of "egusi" soup prepared from the melon seed flour samples.

2. Materials and Methods

2.1 Materials

Melon seeds (*Cucumis mannii* and *Citrullus vulgaris*) were purchased from mile 3 market in Port Harcourt, Rivers State, Nigeria.

Plate 1: Seeds of *Cucumis mannii*

Plate 2: Seeds of *Citrullus vulgaris*

2.2 Methods

2.2.1 Boiling

Boiling was done using the method described by Makinde & Akinoso (2014) with some modifications. The shelled melon seeds were boiled at 100^{o}C for 20 min in the seed to water ratio of 1:10 (w/v). Consequently, the seeds were dried by hot air oven at 60^{o}C for 12 hr prior to milling and stored.

2.2.2 Roasting

The shelled melon seeds were roasted in an oven at 120^{o}C for 1 hr according to the method described by Mohamed *et al.* (2007), ground using a laboratory mill (model MXAC2105, Panasonic, Japan) and stored in plastic bags until required for analysis.

2.2.3 Oven Drying

The shelled melon seeds were oven dried using the method of Chibor *et al.* (2017) with slight modifications. Shelled melon seeds were oven dried at 60^{o}C for 12 hr in a hot air oven (model QUB 305010G, Gallenkamp, UK), ground using a laboratory mill (model MXAC2105, Panasonic, Japan) and stored in plastic bags until required for analysis.

2.2.4 Germination

Unshelled melon seeds were germinated as described by Okoli & Adeyemi (1989). The seeds were sorted and soaked for 2 hr to achieve hydration then rinsed, drained and spread thinly on jute sack for germination to take place. The germination process was closely monitored to prevent discontinuity of germination and mould growth which was achieved by constant wetting and intermittent uniform spreading of the germinating seedlings. Germination was carried out at 28±2^{o}C for 48 hr. The germinated seedlings were thoroughly rinsed with water, drained, shelled and dried in a hot air oven (model QUB 305010G, Gallenkamp, UK) at 60ºC for 12 hr and then milled using a laboratory blender and stored in plastic bags until required for analysis.

2.2.5 Parboiled

The shelled melon seeds were parboiled using the traditional method. The seeds were parboiled at 100^{o}C for 5 min, oven dried at 60^{o}C for 12 hr in a hot air oven (model QUB 305010G, Gallenkamp, UK), milled and stored.

2.2.6 Fermentation

The shelled melon seeds were grounded, placed in a plastic container with a tight lid and sealed. The samples were allowed to ferment at 28±2^{o}C for 24 hr and oven dried at 60^{o}C for 12 hr to bring an end to fermentation, milled and stored as described by Akindahunsi (2004) with some modifications.

2.3 Proximate Composition

Moisture, crude protein, crude fibre, crude fat and total ash contents of the samples were analysed using the method described by Association of Official Analytical Chemists' (AOAC, 2012). Total carbohydrate content of the samples was calculated by difference (subtracting the sum of percentage moisture, crude protein, crude fibre, crude fat, and ash from 100%).

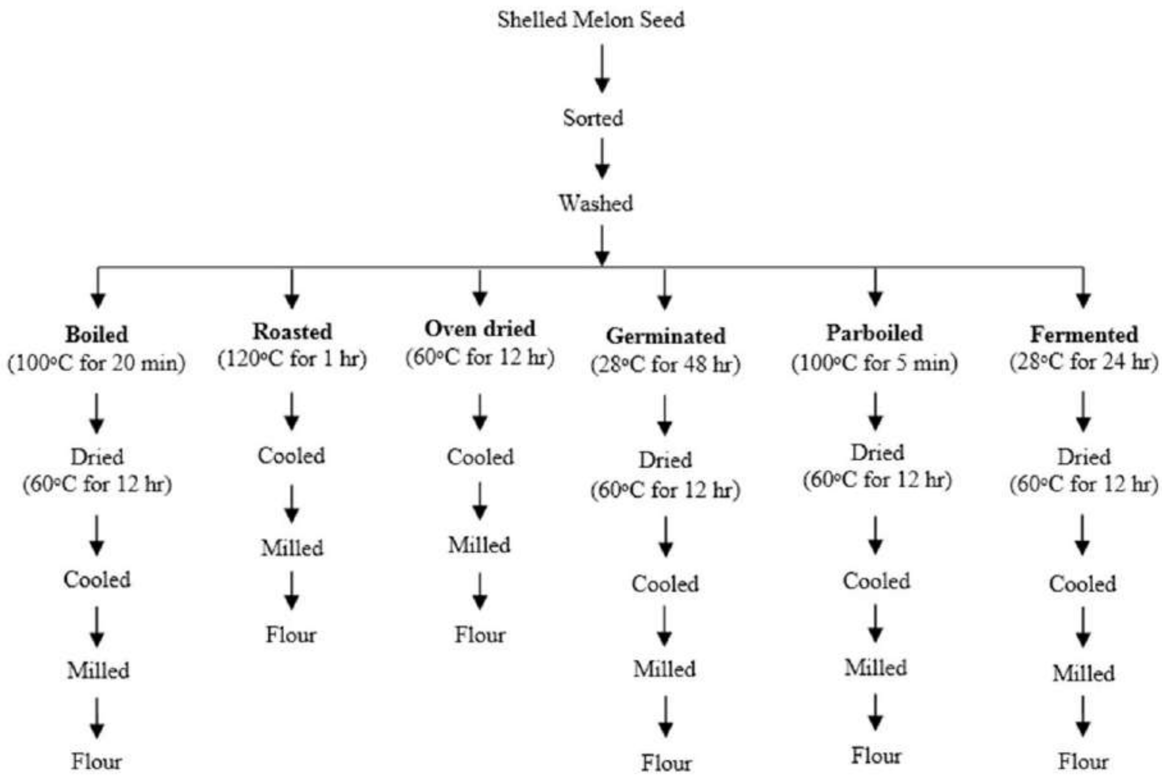

Figure 1: Flow Chart Showing Different Processing Methods of Melon Seeds into Flour

2.4 Functional Properties

2.4.1 Bulk Density

The method of Akpapunam & Markakis (1981) was used. A 10 ml-graduated cylinder was gently filled to mark with the sample. The filled cylinder was gently tapped on a laboratory bench about 10 times until there was no further diminution of the sample level after filling to the 10 ml mark. The procedure was adopted for each of the sample and the bulk density was calculated using the formula:

$$Bulk\ density\ (\text{g/ml}) = \frac{Weight\ of\ Sample}{Volume\ of\ material\ after\ tapping}$$

2.4.2 Water Absorption Capacity

The method described by Elkhalifa *et al.* (2005) was used to determine the water absorption capacity of the melon seed flour samples. Five millilitres of water was added to 1.0 g of the sample in a centrifuge tube. The mixture was sonicated for 1 min to disperse the sample and the suspension was allowed to stand for 30 min. The suspension was then centrifuged after standing at 3500 rpm for 30 min and the water absorbed was calculated using the formula:

$$\text{Water absorbed (ml/g)} = \frac{Volume\ of\ water\ before\ centrifuge - Volume\ of\ water\ after\ centrifuge}{Sample\ weight}$$

$$\text{Water absorbed (g/g)} = \frac{(Wt\ of\ centrifuge\ tube + Sediment) - (Wt\ of\ centrifuge\ tube + Sample)}{Sample\ weight}$$

2.4.3 Oil Absorption capacity

One gram of sample was accurately weighed into a centrifuge tube using electronic weighing balance (model II 512 A Germany) as described by Abbey & Ibeh (1988). Ten millilitres of oil was added to the sample in the centrifuge tube and vigorously homogenized for 1 min to allow the sample dispersed in the liquid. Thereafter, the sample was allowed to stand for 30 min and centrifuged at 3500 rpm for 30 min. The supernatant was turned from the centrifuge tube into a measuring cylinder and the volume was taken using the below formula:

$$\text{Oil absorption capacity (\%)} = \frac{Y - X}{X} x \frac{100}{1}$$

Where;

X = Initial weight of sample

Y = Final weight of the sample

2.4.4 Foam Capacity

Sample weight of 0.5 g was weighed into a beaker using electronic weighing balance (model II 512 A Germany), 50ml of distilled water was added and stir. The sample was homogenized for 20 sec and was poured immediately into a measuring cylinder. Foam capacity was then calculated with the aid of the below formula;

$$\text{Volume of foam} = \textit{Final volume of foam} - \textit{Initial volume}$$

$$\text{Foam capacity (\%)} = \frac{\textit{Volume of foam}}{\textit{Initial foam}} x \frac{100}{1}$$

2.5 Preparation of Egusi Soup

Egusi soup was prepared using the recipe formulated by Kiin-Kabari & Akusu (2017) with slight modification as shown in Table 1. Palm oil was heated in a pot for 2 min. Finely chopped onion was added to the hot oil and stirred for 35 sec. Melon seed flour was added and stirred continuously for 15 min. Five hundred millilitres of water, maggi cube (Nestle Nigeria PLC), pepper and salt (Dangote) were then added and was allowed to cook for 25 min.

Table 1: Recipe Formulation for "Egusi" Soup

Ingredients	O	P	B	G	F	R	C
Melon seed flour (g)	200	200	200	200	200	200	200
Palm oil (ml)	20	20	20	20	20	20	20
Onion (g)	5	5	5	5	5	5	5
Salt (g)	2	2	2	2	2	2	2
Water (ml)	500	500	500	500	500	500	500
Pepper (g)	3	3	3	3	3	3	3
Maggi cube (g)	4	4	4	4	4	4	4

***Source:** Kiin-Kabari & Akusu (2017)

Keys: B = boiled melon seed flour, **O** = oven dried melon seed flour, **F** = fermented melon seed flour, **G** = germinated melon seed flour, **P** = parboiled melon seed flour, **R** = roasted melon seed flour, **C** = control (unprocessed melon seed).

2.6 Sensory Evaluation

Sensory evaluation was performed on the melon (Egusi) soup using the method described by Iwe (2002). The samples were evaluated by selected semi-trained panelists on a 9-Point Likert-type hedonic scale. The team consisted of 25 randomly selected tasters from Food Science Department, Rivers State University, Port Harcourt, Nigeria. Evaluation was on how they liked or disliked each treatment levels with respect to appearance, flavour, thickness, water separation and general acceptability.

2.7 Statistical Analysis

Data obtained were subjected to Analysis of Variance (ANOVA), differences between means were evaluated using Turkey's multiple comparison range test and significance accepted at P≤0.05 level. The statistical package in Minitab 16 computer program was used and all the analyses were carried out in duplicate determinations.

3. Results and Discussion

3.1 Proximate Composition of Melon Seeds Treated with Different Processing Methods

Result for the proximate composition of melon seeds treated with different processing methods is shown in Table 2. Moisture content ranged from 1.21 to 3.86%, with the control (raw *C mannii* and *C vulgaris*) given significantly ($p<0.05$) higher moisture of 3.86% and 3.29%, respectively. Roasting, fermentation and boiling were shown to reduce the moisture content significantly. However, there was no significant difference ($p>0.05$) in the moisture content of the germinated, parboiled and oven dried samples in both varieties from the control (raw melon seed flour). These values were also lower than 5.53, 5.67 and 4.97% moisture contents of raw, germinated and fermented *C. mannii*, respectively reported by Omowaye-Taiwo et al. (2015) and lower than the range of 4.30 to 6.19% reported by Akusu & Emelike (2018). Fokou *et al.* (2004) reported a moisture content that ranged from 4.33 to 7.26% for five different melon seeds. Azhari *et al.* (2014) and Ibeto *et al.* (2012) also reported moisture content of melon seeds to be in the range of 4.27 to 5.63%. Low moisture content in this study confers extended shelf life on the seed flour of *C. mannii* and *C. vulgaris*.

Ash content ranged from 1.5 to 3.09%, with roasted *C. vulgaris* given significantly ($p<0.05$) higher ash content. Boiling, fermentation and roasting increased the ash content of *C. mannii* to 2.30, 2.40 and 2.40%, respectively. Roasting increased the ash content of *C. vulgaris* to 3.09% while ash content of boiled, oven dried, fermented, germinated and parboiled C. vulgaris were not significantly ($p>0.05$) different from that of the control (2.84% for raw C. vulgaris). Azhari *et al.* (2014) and Obasi *et al.* (2012) found ash content of melon seeds to range from 2.40 to 4.33% while Akusu & Kiin-kabari (2015) reported 3.33%. The results showed that the melon varieties and processing methods in the present study have significant amount of ash which are important sources of minerals.

Roasting and germination gave significantly higher fat content of 59.05% and 58.75%, respectively for *C. mannii*. Fat content ranging from 48.10 to 59.05% were within the range reported by Akusu & Emelike (2018). Similar findings were also reported by Mian-Hao & Yanson (2007) and Ibeto et al. (2012) but lower than the range of 45.01-47.20% reported by Oyeleke *et al.* (2012); Kiin-Kabari & Akusu (2014) and Akusu & Kiin-Kabari (2015) which may be attributed to varietal differences and treatment variation. All the melon seed varieties and treatments studied gave high fat contents. This result confirmed the findings of Abiodun & Adeleke (2010) who classified melon seeds as excellent sources of dietary oil.

Significant increase in the protein content of *C. vulgaris* was observed from 23.27% (raw flour), 27.79, 27.28, 27.21 and 26.54% for boiled, roasted, germinated and fermented samples, respectively. This protein values falls within the range of 23.00 to 36.09% of Recommended Daily Allowance for children (NRC, 1989).

roasted *C. vulgaris* seed flours. They could also be a good protein supplement where malnutrition arises, especially in developing countries of Africa where the majority of the population depends on starchy foods (Ejinkeonye *et al.*, 2018).

Table 2: Proximate Composition of Melon Treated with different Processing Methods

Samples	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Crude Fibre (%)	Carbohydrate (%)
BCM	$1.48^{bc}\pm0.01$	$2.30^{b}\pm0.01$	$53.30^{bc}\pm1.04$	$22.98^{c}\pm0.01$	$3.30^{d}\pm0.42$	$16.64^{a}\pm1.39$
OCM	$3.24^{a}\pm0.35$	$1.90^{cd}\pm0.00$	$55.65^{ab}\pm1.01$	$25.64^{ab}\pm0.06$	$2.60^{e}\pm0.00$	$11.14^{ab}\pm2.97$
FCM	$2.09^{b}\pm0.14$	$2.40^{b}\pm0.00$	$55.70^{ab}\pm1.10$	$24.60^{bc}\pm0.14$	$2.50^{e}\pm0.14$	$12.70^{ab}\pm1.70$
GCM	$2.86^{a}\pm0.04$	$1.64^{d}\pm0.00$	$58.75^{a}\pm0.78$	$24.17^{bc}\pm0.56$	$3.95^{cd}\pm0.07$	$8.61^{d}\pm0.83$
PCM	$2.73^{a}\pm0.62$	$1.50^{d}\pm0.00$	$57.75^{ab}\pm0.21$	$25.41^{ab}\pm0.56$	$3.90^{cd}\pm0.00$	$8.70^{d}\pm0.97$
RCM	$1.21^{c}\pm0.11$	$2.40^{b}\pm0.01$	$59.05^{a}\pm0.06$	$24.22^{bc}\pm0.00$	$3.95^{cd}\pm0.07$	$9.16^{cd}\pm1.95$
CCM	$3.86^{a}\pm0.57$	$2.19^{c}\pm0.08$	$52.10^{c}\pm0.01$	$27.12^{a}\pm0.10$	$3.50^{d}\pm0.14$	$9.80^{c}\pm1.80$
BCV	$2.64^{a}\pm0.78$	$2.75^{ab}\pm0.07$	$50.15^{c}\pm0.01$	$27.73^{a}\pm0.56$	$5.00^{bc}\pm0.57$	$11.76^{ab}\pm0.08$
OCV	$2.59^{a}\pm0.00$	$2.85^{ab}\pm0.35$	$48.25^{c}\pm0.06$	$25.56^{ab}\pm0.56$	$4.60^{c}\pm0.85$	$16.14^{a}\pm2.12$
FCV	$2.36^{a}\pm0.67$	$2.75^{ab}\pm0.04$	$48.10^{c}\pm0.71$	$26.54^{a}\pm1.12$	$5.45^{abc}\pm0.50$	$14.79^{ab}\pm0.88$
GCV	$3.09^{a}\pm0.71$	$2.85^{ab}\pm0.07$	$49.60^{c}\pm0.71$	$27.21^{a}\pm0.98$	$7.25^{a}\pm0.07$	$9.98^{c}\pm0.59$
PCV	$2.35^{a}\pm0.30$	$3.00^{ab}\pm0.04$	$52.15^{c}\pm0.07$	$27.05^{a}\pm0.56$	$6.10^{abc}\pm0.14$	$8.34^{d}\pm0.10$
RCV	$1.74^{bc}\pm0.07$	$3.09^{a}\pm0.00$	$50.05^{c}\pm0.07$	$27.28^{a}\pm0.00$	$6.25^{abc}\pm0.07$	$11.58^{ab}\pm0.07$
CCV	$3.29^{a}\pm0.00$	$2.84^{ab}\pm0.21$	$53.15^{bc}\pm0.35$	$23.59^{bc}\pm0.00$	$6.90^{a}\pm0.57$	$11.23^{ab}\pm0.55$

Mean values bearing different superscripts in the same column differ significantly (P<0.05). Values are means ± standard deviation of duplicate determinations.

Keys: BCM = boiled *C mannii* seed flour, OCM = oven dried *C mannii* seed flour, FCM = fermented *C mannii* seed flour, GCM = germinated *C mannii* seed flour, PCM = parboiled *C mannii* seed flour, RCM = roasted *C mannii* seed flour, CCM = control (unprocessed *C mannii* seed). BCV = boiled *C vulgaris* seed flour, OCV = oven dried *C vulgaris* seed flour, FCV = fermented *C vulgaris* seed flour, GCV = germinated *C vulgaris* seed flour, PCV = parboiled *C vulgaris* seed flour, RCV = roasted *C vulgaris* seed flour, CCV = control (unprocessed *C vulgaris* seed).

Increase in protein content during germination may be due to protein synthesis and hydrolysis during sprouting (Asiedu *et al.*, 1993). Fokou *et al.* (2004) reported a range of 24.30 to 41.60% while De Mello *et al.* (2001) and Azhari *et al.* (2014) reported a range of 11.67 to 35.0% for five melon seeds. These melon seed varieties are rich in crude protein content and could be used to enrich food products. Germinated *C. mannii* and *C. vulgaris* could be an alternative source of dietary protein followed by the boiled and

Significantly (p<0.05) higher fibre content was recorded in *C. vulgaris* than those of *C. mannii* with a range of 2.50 to 7.25%. Germination was shown to increase crude fibre content in both varieties while fermentation, boiling and oven drying decreased the crude fibre content significantly in both varieties. Decrease in crude fibre of fermented water melon seed from 3.12 to 2.51% had been reported earlier by Ejinkeonye *et al.* (2018). Fibre content in melon seed can help to provide dietary fibre that would offer protection against cardiovascular disease, obesity and colon cancer and promote the effective functioning of the human digestive tract as reported by Ubom (2007).

Carbohydrate content ranged from 8.34% in parboiled C. vulgaris to 16.64% in boiled *C. mannii*. Boiling, oven drying and fermentation increased the carbohydrate content significantly while germination, parboiling and roasting decreased the carbohydrate content of *C. mannii*. Hydrolysis of carbohydrate to sugar during germination might have led to the low carbohydrate content in the germinated flour (Ejinkeonye *et al.*, 2018).

3.2. Energy Values of C mannii and C vulgaris Seed Flours after Processing

As shown in Figure 2, the energy values of *Cucumis mannii* were significantly higher than those of *Citrullus vulgaris* in all the processing methods, except sample C (raw melon seed flour).

Roasted *C. mannii* gave significantly ($p<0.05$) higher energy value of 664.99kcal/100g followed by germinated *C. mannii* flour. Significantly low energy value of 595.22 kcal/100g was recorded in germinated *C. vulgaris*. High energy value in *C. mannii* could be due to the high fat content of the variety (Akusu *et al.*, 2019). High energy food is desired especially in famine and war-torn locations were the next meal is not easy to come by Ndife *et al.* (2014). As noted by Wardlaw (2004), high-energy foods tend to have a protective effect in the optimal utilization of other nutrients.

3.3. Functional Properties

Foam capacity is related to the rate of decrease in the surface tension of the air-water interface caused by absorption of protein molecules (Peter-Ikechukwu *et al.*, 2016). Good foam capacity can be linked with flexible protein molecules that can reduce surface tension.

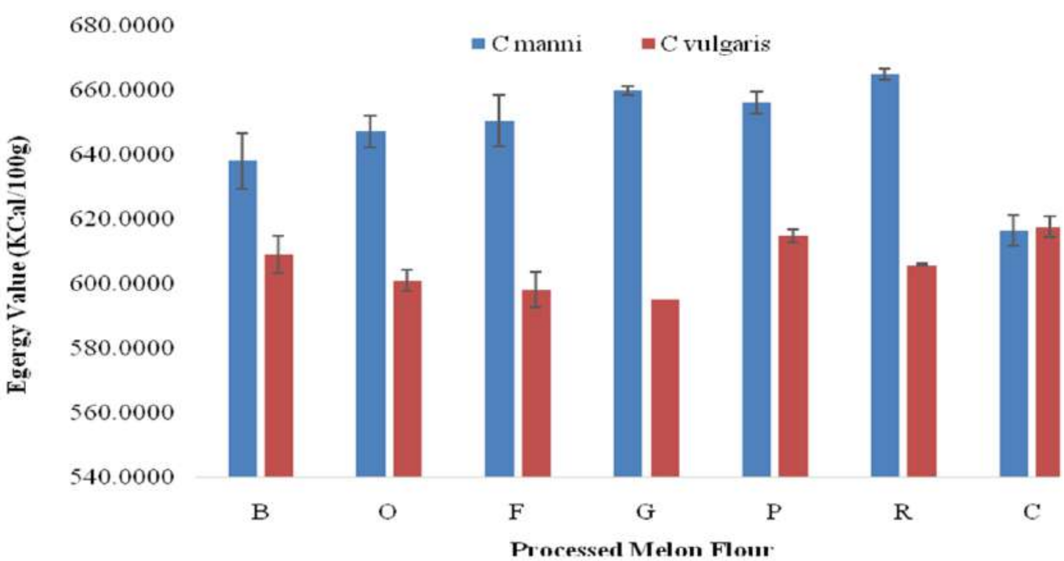

Figure 2: Energy Values of *C. mannii* and *C. vulgaris* Seed Flours after Processing

Keys: B = boiled melon seed flour, O = oven dried melon seed flour, F = fermented melon seed flour, G = germinated melon seed flour, P = parboiled melon seed flour, R = roasted melon seed flour, C = control (unprocessed melon seed).

Highly ordered globular proteins which are relatively difficult to surface denature, gives low foamability (Peter-Ikechukwu *et al.*, 2016). From the result in Table 3, foam capacity ranged from 4.00-10.00 ml in fermented *C. mannii*, fermented *C. vulgaris*, germinated *C. vulgaris* and the control (raw *C. vulgaris* seed flour) with significantly ($p<0.05$) higher foam capacity of 10.00 ml. Parboiled *C. mannii* and roasted C. vulgaris gave significantly low foam capacity of 5.00 and 4.00 ml, respectively. The low foam capacity obtained in these samples may be undesirable in food formulations requiring aeration when whipped such as ice cream (Mempha *et al.*, 2007).

The bulk density of a substance is important in relation to its packaging. Bulk density refers to the weight of a mass of an intact individual unit of the material packed by a specific method (Omowaye-Taiwo *et al.*, 2015). The results revealed that bulk density ranged from 0.354 to 2.392 g/ml. Significantly high values of 2.366 g/ml and 2.392 g/ml was observed in the raw samples (CCM and CCV, respectively) while the least significant value was recorded in the fermented *C. mannii* with regards to the bulk density. High bulk density of the raw samples 2.392 g/ml is an indication that they are denser than the processed samples. Though, high bulk density is a plus in food processing as it brings about a decrease in paste thickness and aid the ease of dispensability of food powders (Udensi & Okaka, 2008; Udensi & Iwe, 2009). This could be the reason why raw melon seed flour is regularly and comfortably being used in soup making. The low bulk density value of the processed samples is desirable in the formulation of weaning foods as it can help increase the calorie and nutrient intake per serving of the infant, thus resulting in healthy growth. Additionally, Peter-Ikechukwu *et al.* (2016) reported that low level of bulk density could be an advantage in the formulation of baby weaning foods. Olawumi *et al.* (2013) also asserted that low bulk density is an advantage in the preparation of complementary foods because high bulk density limits the caloric and nutrient intake per feed of a child, which can result in growth faltering. This therefore placed the processed samples at advantage over the raw melon seed flour for use in food formulation.

Water absorption capacity (WAC) is the ability of moist material to retain water when subjected to an external centrifugal gravity force or compression. It consists of the sum of bound water, hydrodynamic water and mainly, physically trapped water (Ku & Mun, 2008). Significantly high WAC of 1.95 g/g was noticed in boiled, oven dried and germinated *C. mannii*, followed by roasted *C. mannii* seed flour with WAC of 1.740 g/g. WAC for both processed varieties were higher than the control (CCM and CCV) with the values of 0.74 g/g and 0.654 g/g, respectively. These values were lower than results obtained by Peter-Ikechukwu *et al.* (2016) which ranged from 3.40 to 1.79 g/g in the five members of cucurbitaceae family. Generally, the moderate water absorption capacity of the flours is an indication that they would be useful as functional ingredients in food systems such as bakery products where high hydration is required to improve handling characteristics. Water absorption capacity indicates the ability of a product to associate with water in the cases of limited water food materials such as dough and paste. Oil absorption capacity (OAC) ranged from 0.350 to 1.995 g/g. Boiling and roasting increased the OAC of both varieties of melon seed flours. Increase in oil absorption capacity is an indication that melon seeds may possess a high flavour retention potential which could be due to the high hydrophobic protein of the seeds. When applied as a functional agent in food preparations such as meat substitute and extenders, it can serve to increase mouth feel (Omosuli *et al.*, 2009).

raw samples; CCM and CCV were significantly high with the values of 8.30 and 8.40, respectively followed by germinated *C. mannii* with appearance score of 8.05. Taste and flavour values ranged from 4.05-8.25 and 4.25-8.30, respectively.

Table 3: Functional Properties of Melon Treated with different Processing Methods

Samples	Foam Capacity (ml)	Bulk Density (g/ml)	Oil Absorption (g/g)	Water Absorption (g/g)
BCM	$8.000^{c}\pm0.000$	$0.423^{b}\pm0.010$	$1.850^{a}\pm0.071$	$1.950^{a}\pm0.071$
OCM	$9.000^{b}\pm0.014$	$0.402^{bc}\pm0.038$	$1.500^{bc}\pm0.000$	$1.945^{a}\pm0.064$
FCM	$10.000^{a}\pm0.000$	$0.354^{c}\pm0.012$	$0.350^{f}\pm0.071$	$1.640^{c}\pm0.071$
GCM	$9.000^{b}\pm0.014$	$0.431^{b}\pm0.074$	$1.995^{a}\pm0.290$	$1.995^{a}\pm0.007$
PCM	$5.000^{d}\pm0.400$	$0.369^{c}\pm0.055$	$0.900^{e}\pm0.141$	$0.730^{g}\pm0.085$
RCM	$9.000^{b}\pm0.414$	$0.439^{b}\pm0.002$	$1.585^{b}\pm0.007$	$1.740^{b}\pm0.071$
CCM	$9.000^{b}\pm0.014$	$2.366^{a}\pm0.021$	$1.154^{e}\pm0.064$	$0.740^{g}\pm0.071$
BCV	$9.000^{b}\pm0.004$	$0.385^{c}\pm0.021$	$1.550^{b}\pm0.071$	$1.640^{c}\pm0.071$
OCV	$9.000^{b}\pm0.014$	$0.398^{c}\pm0.060$	$1.250^{d}\pm0.071$	$1.545^{d}\pm0.064$
FCV	$10.000^{a}\pm0.000$	$0.437^{b}\pm0.039$	$1.580^{b}\pm0.000$	$1.350^{e}\pm0.071$
GCV	$10.000^{a}\pm0.000$	$0.438^{b}\pm0.035$	$0.950^{e}\pm0.071$	$1.135^{f}\pm0.049$
PCV	$9.000^{b}\pm0.004$	$0.428^{b}\pm0.002$	$1.100^{e}\pm0.141$	$1.895^{ab}\pm0.007$
RCV	$4.000^{e}\pm0.000$	$0.382^{c}\pm0.020$	$1.590^{b}\pm0.014$	$1.640^{c}\pm0.071$
CCV	$10.000^{a}\pm0.000$	$2.392^{a}\pm0.061$	$1.240^{d}\pm0.071$	$0.645^{g}\pm0.078$

Mean values bearing different superscripts in the same column differs significantly ($p<0.05$) ± standard deviation of duplicate determinations.
Keys: BCM = boiled *C mannii* seed flour, OCM = oven dried *C mannii* seed flour, FCM = fermented *C mannii* seed flour, GCM = germinated *C mannii* seed flour, PCM = parboiled *C mannii* seed flour, RCM = roasted *C mannii* seed flour, CCM = control (unprocessed *C mannii* seed). BCV = boiled *C vulgaris* seed flour, OCV = oven dried *C vulgaris* seed flour, FCV = fermented *C vulgaris* seed flour, GCV = germinated *C vulgaris* seed flour, PCV = parboiled *C vulgaris* seed flour, RCV = roasted *C vulgaris* seed flour, CCV = control (unprocessed *C vulgaris* seed).

3.4. Sensory Properties

The sensory evaluation of the "egusi" soup samples revealed that scores for appearance ranged from 4.55-8.40, with significantly low value recorded in roasted *C. vulgaris* as presented in Table 4. The appearance score for

All the soup samples prepared with treated C. vulgaris flours recorded significantly high thickness ranging from 7.25 to 8.40, except roasted and boiled samples which scored 4.10 and 5.20, respectively. Thickness is probably affected by high viscosity of the melon seed flour as reported by Akusu & Kiin-Kabari

(2015). These reports are similar to that of Akusu & Kiin-Kabari (2013) on the relationship between viscosity and other functional properties of watermelon seed flour. *C. vulgaris* and the raw melon flour samples showed higher overall acceptability than the processed *C. mannii* samples. Preference for *C. vulgaris* may be associated with its variety as it is mainly consumed, cherished and accepted by the populace more than all other varieties (Akusu & Emelike, 2018). However, roasted *C. vulgaris* received the least acceptability probably due to high water separation.

4. Conclusion

The results revealed that all the melon seed varieties irrespective of the treatments studied have high fat contents. Hence, the seeds are classified as excellent sources of dietary oil. Germination process led to an increase in protein content. This presents germinated *C. mannii* and *C. vulgaris* as alternative source of dietary protein and hence, they could be used to enrich food products. Processing resulted to a significant decrease in the bulk density of the melon seed flour samples.

Table 4: Sensory Properties of Melon Seed Flours Treated with Different Processing Methods

Samples	Appearance	Taste	Flavour	Water Separation	Thickness	Overall acceptability
BCM	5.80^{b}±1.135	5.20^{cd}±1.173	5.05^{cd}±1.132	5.30^{c}±1.055	4.40^{c}±1.106	5.10^{cd}±1.004
OCM	5.59^{b}±1.105	4.75^{d}±1.088	4.90^{cd}±1.217	5.20^{c}±1.196	5.55^{bc}±1.115	5.45^{cd}±1.138
FCM	5.35^{b}±0.033	4.05^{d}±1.005	4.25^{d}±1.103	4.35^{d}±0.183	6.20^{b}±1.006	5.55^{cd}±1.008
GCM	8.05^{a}±0.826	7.10^{ab}±1.186	6.75^{b}±1.209	7.40^{b}±0.153	8.25^{a}±1.020	8.05^{a}±0.759
PCM	6.00^{b}±1.257	6.20^{bc}±1.152	5.85^{bc}±1.226	5.35^{c}±1.011	4.90^{bc}±0.113	6.10^{c}±1.021
RCM	5.45^{b}±1.191	5.20^{cd}±1.022	5.30^{cd}±1.010	7.10^{bc}±1.252	4.55^{c}±0.220	5.35^{b}±1.231
CCM	8.30^{a}±1.031	8.25^{a}±.070	8.25^{a}±0.910	5.20^{c}±1.046	8.65^{a}±0.933	8.65^{a}±0.813
BCV	6.05^{ab}±1.072	6.25^{b}±1.010	6.15^{b}±1.006	5.85^{cd}±1.001	5.20^{bc}±1.003	6.20^{c}±1.176
OCV	7.40^{ab}±0.188	7.25^{ab}±1.182	7.05^{ab}±1.104	7.15^{bc}±0.089	7.20^{a}±1.281	7.15^{bc}±1.182
FCV	7.60^{ab}±0.995	7.35^{ab}±1.031	7.00^{ab}±1.211	7.40^{b}±0.142	7.65^{a}±0.128	7.60^{ab}±1.103
GCV	7.50^{ab}±1.147	6.65^{b}±1.387	7.05^{ab}±0.050	6.45^{bc}±0.731	7.30^{a}±1.010	7.65^{ab}±1.002
PCV	6.60^{ab}±1.092	6.65^{b}±1.387	6.75^{b}±0.293	6.45^{bc}±1.101	7.40^{a}±1.501	7.00^{bc}±1.257
RCV	4.55^{bc}±0.112	4.50^{d}±1.960	4.65^{d}±1.059	8.65^{a}±0.059	4.10^{c}±0.024	4.30^{e}±0.025
CCV	8.40^{a}±0.046	8.25^{a}±1.293	8.30^{a}±0.014	5.35^{c}±0.018	8.40^{a}±0.095	8.55^{a}±0.887

Mean values bearing different superscripts in the same column differ significantly ($p<0.05$) ± standard deviation of 25 responses.

Keys: BCM = boiled *C mannii* seed flour, OCM = oven dried *C mannii* seed flour, FCM = fermented *C mannii* seed flour, GCM = germinated *C mannii* seed flour, PCM = parboiled *C mannii* seed flour, RCM = roasted *C mannii* seed flour, CCM = control (unprocessed *C mannii* seed). BCV = boiled *C vulgaris* seed flour, OCV = oven dried *C vulgaris* seed flour, FCV = fermented *C vulgaris* seed flour, GCV = germinated *C vulgaris* seed flour, PCV = parboiled *C vulgaris* seed flour, RCV = roasted *C vulgaris* seed flour, CCV = control (unprocessed *C vulgaris* seed).

Low bulk density value of the processed samples is desirable in the formulation of weaning foods as it can help increase the calorie and nutrient intake per serving of the infant, thus resulting in healthy growth. Moderate water absorption capacity observed in the processed melon seed flours is an indication that they would be useful as functional ingredients in food systems such as bakery products where high hydration is required to improve handling characteristics. The raw melon seed fours including germinated *C. mannii*, *C. vulgaris* and fermented *C. vulgaris* received higher overall acceptability.

Conflict of interest

The authors declare that there are not conflicts of interest.

Ethics

This Study does not involve Human or Animal Testing.

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