



## **Comparative Study on the Nutritional and Antioxidant Components of Fruit Parts of *Citrullus lanatus***

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. Author KIU designed and supervised the study. Authors SKN, VHAE and AAO performed the experimental details, managed the literature searches and statistical analyses while author UCO wrote the protocol and first draft of the manuscript. All authors read and approved the final manuscript.*

### **Article Information**

DOI: 10.9734/EJNFS/2020/v12i1130317

Editor(s):

(1) Dr. Johnson Akinwumi Adejuyitan, Ladoko Akintola University of Technology (LAUTECH), Nigeria.

Reviewers:

(1) Md Zakiur Rahman, Dhaka University, Bangladesh.

(2) Nouredaim Elnoma Elbadawi, Shaqra University, Saudi Arabia.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/63088>

**Original Research Article**

**Received 20 September 2020**  
**Accepted 23 November 2020**  
**Published 12 December 2020**

### **ABSTRACT**

**Aim:** *Citrullus lanatus* is a fruit widely consumed for its pulp though incompletely, as its other parts (seed and rind) are discarded and may possibly offer bioactive compounds involved in ameliorating certain disease conditions. Hence, this study aimed at comparatively investigating the nutritional composition and antioxidant properties of the seed, pulp and rind of *C. lanatus* so as to inform the inclusion of these different parts into the fare of the people.

**Methodology:** Standard analytical methods of Association of Official Analytical Chemists were used to determine proximate, phytochemical, vitamin, mineral and antioxidant aspects of the fruit parts. The results were analyzed using Student's t-test at .05.

**Results:** The proximate analysis showed a high moisture value in the pulp (93.34 +/- .82) followed by the rind (77.11 +/- 3.44) and the seed (10.00 +/- .48). High crude protein and fiber contents were both noted in the seed followed by the rind and pulp. Mineral determinations revealed potassium to be abundant in the rind (452.31mg/kg) than the seed (305.7mg/kg) and the pulp (100.5mg/kg), followed by calcium occurring more in the rind (292.61mg/kg) than in the pulp

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(257.21mg/kg) and seed (227.45mg/kg) and then manganese being the least concentrated among the minerals. The investigated phytochemical principles revealed the highest concentration of cardiac glycosides in the seed (14.82 +/- .66) than the rind (1.95 +/- 0.80) and pulp (1.10 +/- 0.17), followed by saponins occurring most in the rind (12.05 +/- 3.91) than the seed (10.17 +/- 0.63) and pulp (.13 +/- .01). The seed had the highest DPPH scavenging activity followed by the rind and pulp respectively. The seed also showed a higher reducing power and lipid peroxidation capacities than the other fruit parts suggesting a potent property for antioxidant activity in the fruit parts of *C. lanatus*.

**Conclusion:** The findings imply that both seed and rind of *C. lanatus* can be good sources of nutritional, phytochemical and antioxidant components in addition to the pulp which is commonly consumed and these may be implicated in management of certain diseases with further evidential research.

**Keywords:** *Citrullus lanatus*; nutritional; antioxidant; seed; rind; pulp.

## 1. INTRODUCTION

Fruits are seed containing organs found in the ripened ovary of a flower. They are the parts of plants that produce seeds and are mostly fleshy and juicy. However, some may be dried such as cereal, grains, nuts and legume pods [1].

Fruits form a crucial part of human diet because they provide health benefits and help in preventing illnesses. They contain variety of nutrients including vitamins, minerals, bioactive compounds, and phytochemicals, especially antioxidants which help in reducing risk of chronic diseases. They are naturally rich in fiber, potassium, iron, vitamin C and low in sodium, calories and fat [2]. Fruit consumption has increased worldwide owing to its taste and health benefits [3,4]. However, the increase in consumption of fruits also implies an increment in the volume of waste generated, especially peels and seeds. Furthermore, byproducts (peel and seed) from different fruits can be important sources for valuable chemicals [5].

Containing a high percentage of water averaging 85%, fats and protein in very small varying amounts, a fair proportion of carbohydrate present as cellulose, starch in small quantity and sugar, fruits offer a gamut of positive health impacts that range from low energy value to high fiber content. They are known for their high micronutrient concentrations including carotene or pro-vitamin A, vitamin K, ascorbic acid, riboflavin, iron, iodine and other mineral elements [6]. Vitamin A in fruits is present as the precursor carotenes (alpha, beta and gamma) which can be converted to the vitamin in the body. Fruits supply vitamin and minerals in quantities high enough to meet the body's daily requirements [7]. They have been linked to the management of anemia because of their vitamin C content. When

consumed with meals, they enhance iron status of the individual by improving its absorption<sup>8</sup>. Research studies have shown that a diet rich in the vitamin antioxidants, C and E and the carotenoids is associated with improved health and a lower risk of coronary heart disease and cancer [8-10]. The fiber content of fruits and vegetables has been reported to have beneficial effects on blood cholesterol and they aid in the prevention of large bowel diseases [11]. It has also been reported that populations that consume diet rich in fruits have significantly lower rates of many types of cancers [12]. Attention in recent time is turning to water melon as one of these fruits which can provide the body with the basic nutrients needed for a healthy and balanced life.

Water melon, botanically known as *Citrullus lanatus* has its origin from the hot, dry regions around the Mediterranean. Its cultivation has extended to tropical and subtropical regions on the American continent [13]. *C. lanatus* is a herbaceous creeping plant of the family Cucurbitaceae [14]. *C. lanatus* fruit is round, oval or oblong, with a light green to very dark green skin, variously patterned or striped and red, yellow or orange flesh. The seeds are flat and smooth, varying in size and may be white tan, brown, black red, or green. The *C. lanatus* fruit has a smooth exterior rind (green, yellow and sometimes white and a juicy, sweet interior flesh). It is mostly cultivated in the Northern part of Nigeria for its fruit and vegetative parts [15]. The pulp is widely consumed majorly as a fun accompaniment [16,17].

In Nigeria as well as most other countries, variety of fruits are consumed on a daily basis, and they form an integral part of diet but most times only the fleshy pulp of these fruits are consumed neglecting the seed and the rind, which may be

as well nutritionally relevant as the pulp. Hence, a need for comparative evaluation of the nutritional and antioxidant levels of the different parts of the plant so as to inform the inclusion of the rind and seed into the fare of the people with a view to fostering food security and improving health needs through the provision of daily nutritional requirements of the body.

## 2. MATERIAL AND METHODS

### 2.1 Materials

#### 2.1.1 Collection and identification of sample

Fresh water melon fruits were purchased from Nkwo-Amenyi market Awka, Anambra State, Nigeria. The plant sample was identified and authenticated by a taxonomist at the Botany laboratory, Department of Botany, Nnamdi Azikiwe University Awka and subsequently deposited at the herbarium with Voucher number 189. This research was carried out at Natural Product Research & Development Laboratory, Special Research Centre, Nnamdi Azikiwe University, Awka from June to December, 2019.

### 2.2 Methods

#### 2.2.1 Preparation of sample

The fruits were thoroughly washed after which it was sliced using a home choice knife. The green bark was carefully scrapped out and the seeds and rind were separated from the pulp. These seeds, rind and pulp of the fruit were used for the study. They were dried in an oven with air flow at 50°C for 96 hours after which they were ground using a Corona manual grinder. The powdered samples were stored in an air-tight container until further analysis. Exactly 5g of powdered sample of the seed and rind respectively were immersed in 100ml of 70% ethanol for 24 hours. Thereafter, the mixture was filtered using Whatman No. 4 paper and ethanol evaporated using a Soxhlet apparatus.

#### 2.2.2 Proximate analysis of *C. Lanatus*

Proximate analysis was determined on the ethanol extract of the fruit parts using standard methods according to Association of Official Analytical Chemists [18].

#### 2.2.3 Qualitative phytochemical screening of *C. lanatus*

The ethanol plant extract was screened for the presence of alkaloids, flavonoids, saponins,

cardiac glycosides, tannins, sterols, reducing sugars and terpenoids according to standard methods as described by Harborne [19].

#### 2.2.4 Mineral content determination of *C. lanatus*

Determination of Calcium, Magnesium, Potassium, Iron, Zinc and Manganese were all carried out using Atom Analyzer method in an Atomic Absorption Spectrophotometer 969 instrument [20].

#### 2.2.5 Vitamin content determination of *C. lanatus*

Vitamin A, C and E levels were all determined using Atom Analyzer method in an Atomic Absorption Spectrophotometer [20].

#### 2.2.6 Antioxidant analysis

##### 2.2.6.1 Free radical scavenging activity

The stable 2, 2-diphenyl-1-picryl hydrazyl radical (DPPH) was used for the determination of free radical scavenging activity of the methanol extract of the samples [21]. Different concentrations of the extract (0-1000µg/ml) were mixed with an equal volume of methanolic solution of DPPH (100 µM) in a test tube. The mixture was shaken and kept in dark for 30 minutes. The absorbance was read at a wavelength of 517 nm using spectrophotometer 969 instrument. Beta Hydroxyl acid (BHA) was used as standard. The percentage scavenging activity was calculated using the formula:

$$\%RSA = [(A_{DPPH} - A_s) / A_{DPPH}] \times 100$$

Where  $A_s$  is the absorbance of the test solution with the sample and  $A_{DPPH}$  is the absorbance of DPPH solution. The  $EC_{50}$  (concentration of sample at 50% RSA) was calculated from the graph of %RSA against the sample concentration.

##### 2.2.6.2 Reducing power assay

The reducing power was determined according to the principle of increase in the absorbance of the reaction mixture<sup>22</sup>. Various concentrations of methanol extract of the samples (0-1000µg/ml) were mixed with 2.5 ml of 0.2 M sodium phosphate buffer (pH 6.6) and 2.5 ml of 1% potassium ferricyanide. The mixture was incubated at 50°C for 20 minutes. 2.5 ml of 10%

trichloroacetic acid was added and the mixture centrifuged at 1000 rpm for 8 minutes. The upper layer (5 ml) was mixed with 5 ml of deionized water followed by the addition of 1 ml of 0.1% ferric chloride. The absorbance was measured at 700nm. The graph of absorbance at 700nm against the extract concentrations was plotted. BHA was used as the standard according to the method of Barros et al. [22].

#### 2.2.6.3 Assay of inhibition of lipid peroxidation using TBA reactive substance

Determination of the extent of inhibition of lipid peroxidation was carried out using homogenate of the brain of a goat [22]. The brain was gotten from a goat of approximately 60 kg body weight purchased from Kwata abattoir at Awka. The brain was dissected and homogenized with pestle and mortar in an ice cold Tris-HCl buffer (pH 7.4, 20mM) to produce 10% w/v brain homogenate which was centrifuged at 3000 rpm for 10min. An aliquot (0.1 ml) of the supernatant was incubated with 0.2 ml of the sample extract at various concentrations (0-1000 µg/ml), in the presence of 0.1 ml of 10µM ferrosulphate and 0.1 ml of 0.1mM ascorbic acid at 37°C for 1hr. The reaction was stopped by the addition of 0.5 ml of 28% TCA followed by the addition of 0.38 ml of 2% TBA. The mixture was then heated at 80°C for 20 minutes. After centrifugation at 3000rpm for 10mins to remove the protein, the colour intensity of the malondialdehyde (MDA)-TBA complex in the supernatant was measured by its absorbance at 532nm. The inhibition ratio (%) was calculated using the following formula:

$$\text{Inhibition ratio (\%)} = [(A-B)/A] \times 100\%$$

Where A and B are the absorbance of the control and the compound solution respectively. The extract concentration providing 50% lipid peroxidation inhibition (EC<sub>50</sub>) was calculated from the graph of antioxidant activity percentage against the extract concentrations. BHA was used as the standard.

#### 2.2.7 Statistical analysis

All statistical analyses were performed using Statistical Package for the Social Sciences International Business Machines (SPSS IBM) version 23.0 (SPSS Inc., Illinois Chicago, USA). Data were presented as mean±SD and further subjected to Samples *t*-test at 95% confidence level considered as significant.

### 3. RESULTS

#### 3.1 Proximate Composition of the Seed, Pulp and Rind of *C. lanatus*

The compositions of the seed, pulp and rind of *C. lanatus* are shown in Table 1. The percentage compositions are expressed as mean values of the triplicate determination and presented as mean ± SD. The ash content was highest in the seed (7.03 ± 0.11) with no significant difference between the pulp (1.28 ± 0.35) and rind (1.98 ± 0.60). However, the pulp had the highest moisture content (93.34 ± 0.82) compared to the seed and the rind. The percentage total lipids content was highest in the seed (9.63 ± 0.62) when compared to the pulp and the rind which have 0.50 ± 0.14 and 0.90 ± 0.14, respectively. Crude protein was highest in the seed (37.50 ± 4.10) followed by the rind (1.10 ± 0.30) while the pulp has the least value (0.40 ± 0.06). Crude fiber was highest in the seed (25.95 ± 2.90) compared to the pulp and the rind with 0.30 ± 0.21 and 1.50 ± 0.00 respectively. The total carbohydrate of the pulp was highest (50.51 ± 64.86) compared to the rind (17.42 ± 3.87) and the seed (9.90 ± 1.23).

#### 3.2 Mineral Content of Seed, Pulp and Rind of *C. lanatus*

The results in Table 2 show the mineral contents of the seed, rind and pulp of *C. lanatus*. All the parts have considerable amounts of the investigated minerals. Both potassium and calcium were highest in the rind with 452.31 mg/kg and 292.61 mg/kg respectively when compared to the seed and pulp. All the parts of the fruit have negligible amount of manganese with the pulp having the least amount of 0.041 mg/kg.

#### 3.3 Phytochemistry of the Seed, Pulp and Rind of *C. lanatus*

The phytochemical compositions of different parts of *C. lanatus* are presented in Table 3. Generally, all the investigated parts constitute minute quantities of researched anti-nutrients except phytate and oxalate. The seed contain the highest concentration of phytate as well as cardiac glycoside 16.5 ± 0.41 and 14.82 ± 0.66, respectively but a very negligible amount of oxalate (0.35 ± 0.02). Meanwhile, the saponin content was highest in the rind (12.05 ± 3.91) when compared to the other two parts. The pulp

has no detectable quantity of phytate and oxalate but constitute a negligible amount of terpenoids.

### 3.4 Vitamin Composition of Seed, Pulp and Rind of *C. lanatus*

The vitamin compositions of the seed, pulp and rind of *C. lanatus* are shown in Table 4. Generally, all the investigated parts of the fruit showed considerable content of vitamin A with the pulp being highest (26 +/- 7.07). Similarly, the pulp has the highest vitamin C content (132.0 +/- 2.81) with the seed and rind having equivalent contents. However, the vitamin E content was highest in the seed compared to the pulp and the rind.

### 3.5 Antioxidant Analysis of the Seed, Pulp and Rind of *C. lanatus*

#### 3.5.1 DPPH scavenging activity

The free radical (DPPH) scavenging activities of the seed, pulp and rind of *C. lanatus* as presented in the Fig. 1. showed that all the investigated parts of the sample exhibited a

significant increase in the inhibition of the DPPH radical in a concentration dependent manner with the seed showing the highest inhibitory activity.

#### 3.5.2 Reducing power of the seed, pulp and rind of *C. lanatus*

The result of the reducing power capacity of the seed, pulp and rind of *C. lanatus* is presented in the Fig. 2. The result showed that all the investigated parts of the sample exhibited a significant increase in the reducing power capacity in a concentration dependent manner with the seed showing the highest activity.

#### 3.5.3 Lipid peroxidation activity of the seed, pulp and rind of *C. lanatus*

Lipid peroxidation activity as obtained for the seed, pulp and rind of *C. lanatus* is graphically presented in Fig. 3. The result revealed that the inhibitory activity of the rind significantly increased at a concentration of 250 µg/ml. However, as the concentration increased, the seed part showed the highest inhibitory activity when compared to the pulp and the rind.

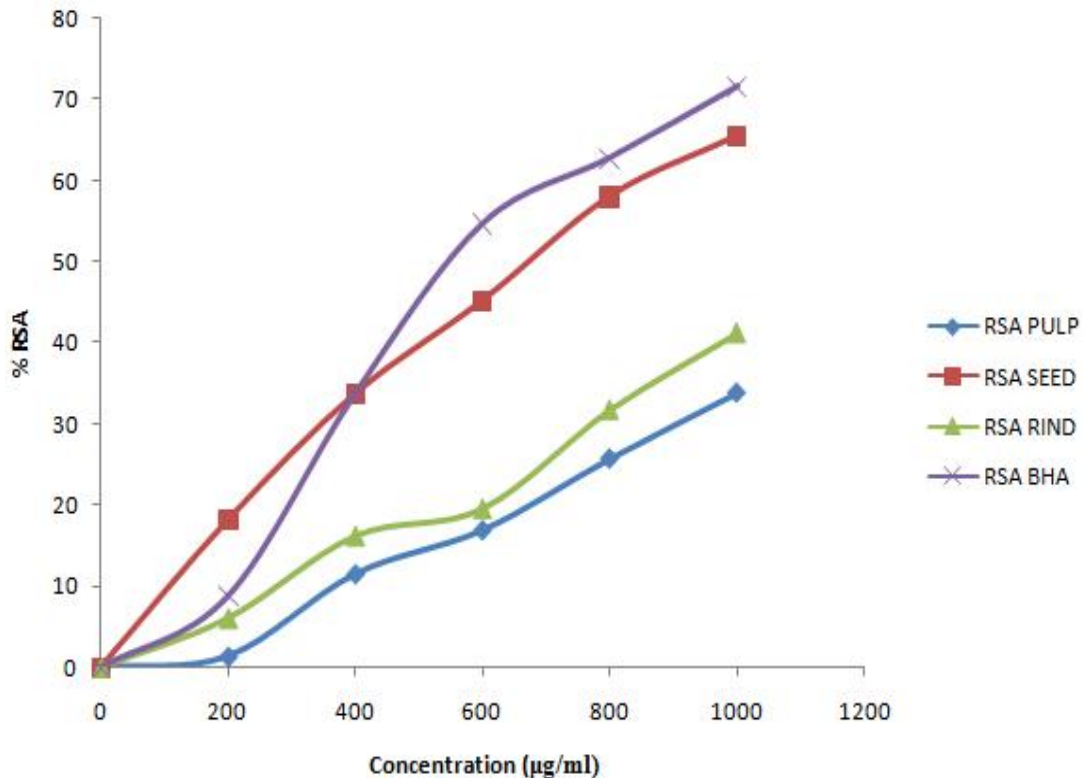


Fig. 1. Effect of seed, pulp and rind on free radical (DPPH) scavenging activity

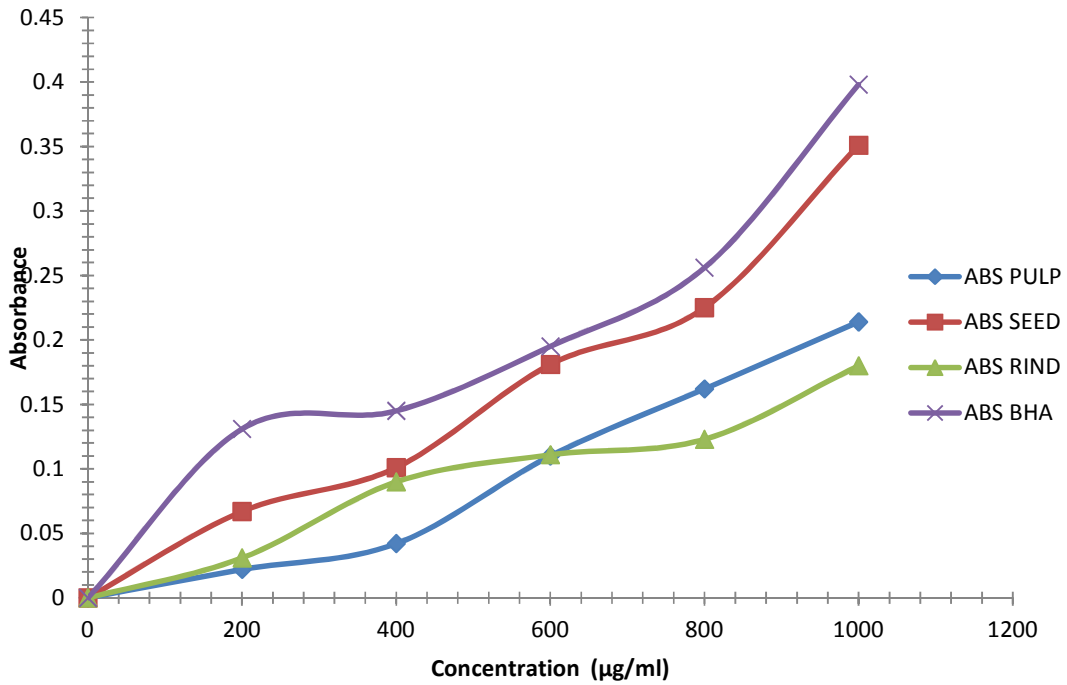


Fig. 2. Effect of seed, pulp and rind on the reducing power capacity

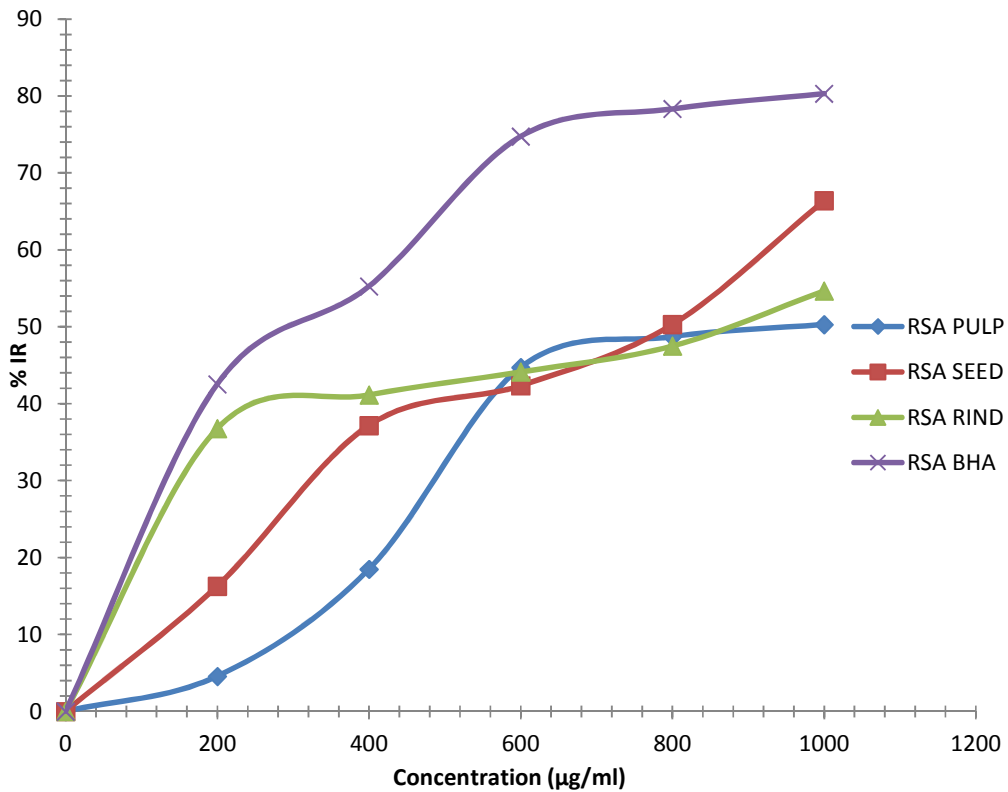


Fig. 3. Effect of seed, pulp and rind on the inhibition of lipid peroxidation activity

**Table 1. Proximate content of *C. lanatus***

Parameters (%)	Seed	Pulp	Rind
Ash	7.03 +/- .11	1.28 +/- .35	1.98 +/- .60
Moisture	10.00 +/- .48	93.34 +/- .82	77.11 +/- 3.44
Total lipids	9.63 +/- .62	.50 +/- .14	.90 +/- .14
Crude protein	37.50 +/- 4.10	.40 +/- .06	1.10 +/- .30
Crude fiber	25.95 +/- 2.90	.30 +/- .21	1.50 +/- .00
Total Carbohydrate	9.90 +/- 1.23	50.51 +/- 64.68	17.42 +/- 3.87

Data are expressed as Mean + SD of triplicate determinations

**Table 2. Mineral contents of *C. lanatus***

Minerals (mg/kg)	Seed	Pulp	Rind
Ca	226.45	257.21	292.61
Mg	15.00	12.19	13.98
K	305.7	100.50	452.31
Fe	2.70	.19	.10
Zn	8.10	5.28	.31
Mn	.40	.04	.05

Data are expressed as mean of triplicate determinations

**Table 3. Phytochemistry of *C. lanatus***

Parameter (mg/g)	Seed	Pulp	Rind
Total phenol	5.30 +/- .45	.15 +/- .07	4.09 +/- 1.18
Flavonoid	7.58 +/- .21	3.11 +/- .14	4.85 +/- .51
Cardiac glycoside	14.82 +/- .66	1.10 +/- .17	1.95 +/- .80
Saponins	10.17 +/- .63	.13 +/- .01	12.05 +/- 3.91
Phytate	16.50 +/- .41	ND	3.92 +/- .29
Oxalate	.35 +/- .02	ND	1.75 +/- .62
Terpenoids	9.21 +/- 1.41	.11 +/- .03	8.10 +/- 1.58

Data expressed as Mean  $\pm$  SD of triplicate determinations

**Table 4. Vitamin content of *C. lanatus***

Parameter ( $\mu$ g/g)	Seed	Pulp	Rind
Vitamin A	15.00 +/- .07	26.00 +/- 7.07	16.00 +/- 2.83
Vitamin C	97.50 +/- 3.54	132.00 +/- 2.81	97.50 +/- 3.54
Vitamin E	64.00 +/- 5.66	41.50 +/- 2.12	63.50 +/- 4.95

Data expressed as Mean  $\pm$  SD of triplicate determinations

#### 4. DISCUSSION

In the present study, the nutritional composition and antioxidant potentials of the pulp, rind and seed of *C. lanatus* were investigated and compared. This is sequel to the fore-going knowledge of the important roles plants play in the prevention and management of certain illnesses coupled with the fact that there is dearth of information on the nutritional compositions of plant parts of *C. lanatus*, a fruit best known for its hydrating effect.

The findings of the study revealed for the proximate analysis an ash content higher in the

seed followed by the pulp and rind respectively. This was, however, not significantly different ( $P = 0.48$ ). These values were lower compared to that of *Cucurbita spp* reported in a study conducted in 2011 [23] though they were higher than that of *Cumis melo* var. *agrestis* seeds reported in a different study in 2008 [24]. The proportion of ash content is a reflection of the mineral contents present in the food materials of the mineral contents present in the food materials [25].

The pulp had the highest moisture content compared to the seed and rind. This finding is expected owing to the fact that majority of the water content of the fruit resides in the pulp.

These values were higher than 74.37% for *Cucurbita* spp [23] and 75 - 91.33% for the pulp and 4.4 - 15.2% for the seeds of *C. maxima* reported in a related study [26]. Similar values of 4.50 +/- 0.73 were reported for *Cucumis melo* var. *agrestis* [24]. The moisture content of any food is an index of its water activity [27] and it is used as a measure of stability and susceptibility to microbial contamination [28].

The percentage total lipids content was highest in the seed compared to that obtained for the pulp and rind. In support of this finding, seeds of plants that have been studied by other researchers contain relatively higher amounts of lipids than other parts studied comparatively. For example, the values were lower than the 52.13% +/- 0.12 of *Cucurbita maxima* seed [29]. However, the values were higher compared with 1.69% for *Cucurbita* spp seeds [23]. Dietary fats function in the increase of palatability of food by absorbing and retaining flavours [30]. Fats are also vital in the structural and biological functioning of the cells and help in the transport of nutritionally essential fat soluble vitamins [25].

Crude protein was found to be highest in the seed followed by the rind and pulp respectively. These values are lower than that reported for *C. maxima* seeds in a similar study [31]. Proteins are major constituents of most structural and cellular components in any living organism. They compose of amino acids and these values suggest as stipulated [32] that the seeds can provide the basic protein requirements for humans which are based at 23-56 g.

The study showed varying amounts of crude fiber in the seed, pulp and rind of *C. lanatus*. Similar values were recorded for *Curcubita maxima* seeds [26,29]. Fiber helps in the maintenance of human health and has been known to reduce cholesterol level in the body [33]. A low fiber diet has been associated with heart diseases, cancer of the colon and rectum, varicose veins, phlebitis, obesity, appendicitis, diabetes and constipation [34,35]. The fiber contents of vegetables vary owing to many reasons including growth condition (climate, soil), time of harvest and species. The findings of this study thus indicate the seed as a relatively sufficient source of fiber as it is usually suggested that the seeds be consumed alongside the pulp to aid digestion.

The carbohydrate content of the seeds, rind and pulp were found to be highest in the pulp followed by the rind and seed in that order. These values were however not significantly

different ( $P = 0.32$ ). The carbohydrate content obtained from these fruit parts is sufficient to classify *C. lanatus* as a carbohydrate-rich fruit which is able to supply most of the body's energy requirement.

The present study also demonstrated mineral compositions of the seed, pulp and rind of *C. lanatus*. According to the findings, calcium concentrations of the fruit parts obtained in the study were found to be lower compared to *Cucurbita maxima* reported in a related work [29]. Based on this report, the fruit parts are enough to provide the body's daily calcium requirement as the mineral is essential for bone and teeth development.

The potassium concentration values obtained in this study compares significantly with the value reported for *Cucurbita maxima* [29]. Potassium plays an important role in the human body and sufficient amounts of it in the diet protects against heart disease, hypoglycaemia, diabetes, obesity and dysfunction. Adequate intake of this mineral from the diets has been found to lower blood pressure by antagonizing the biological effects of sodium [36].

The iron contents of rind, seed and pulp obtained in the study were also low compared to iron contents reported by other researchers for fruit parts of other plant samples as in *Curcubita maxima* seed [37]. As iron deficiency is a major problem in women's diets in the developing world, particularly among pregnant women and especially in Africa [37], this implies that these samples would serve as blood building foods and should be recommended for human consumption [31].

Similarly, the zinc concentrations of rind, seed and pulp observed in this study were found to be comparable with previous works. The pulp and seed parts had higher values than the rind which compares with the findings of Mohammed [38] who reported higher pumpkin seed and pulp Zn contents than the rind. Zinc is highly recommended in diets as it is required for proper sexual organ functioning and enzyme activity. High values of zinc are usually associated with high-protein food stuff, whereas low levels are obtained from food rich in carbohydrates [39]. Though information on comparative nutritional composition of *C. lanatus* are not replete, these findings may serve as a baseline for further work.

Manganese is an essential metal because it is required for proper immune function, regulation



of blood sugar and cellular energy, reproduction, digestion, bone growth, blood coagulation, and homeostasis and defense against reactive oxygen species. The beneficial effects of manganese are due to the incorporation of the metal into metalloproteins thus aiding biochemical functions. As the fruit parts of *C. lanatus* contain low amounts of Mn, it implies that at least it can provide minimally concentrations of Mn for basic enzyme action.

The results of anti-nutritional composition of seed, pulp and rind of *C. lanatus* were investigated in the present study. Oxalate contents obtained in the seed and rind were found to be higher than for those reported for *Cucurbita pepo L.* (a similar species) by Elinge et al. [40]. Oxalate is a concern because of its negative effect on mineral availability, presence of oxalate in food causes irritation in the mouth [41] and interfere with absorption of divalent minerals particularly calcium by forming insoluble salts [42]. The level of oxalate in the samples is not high to pose any health threat though it is important that no oxalate is found in the pulp as this is more edible part of the fruit.

The saponins values reported for the seed, pulp and rind were in agreement with the  $.11 \pm .01\%$  for *C. lanatus* reported by Nwaoguikpe et al. [43]. Saponins are extremely poisonous, as they cause hemolysis of blood [44].

The phytate contents of the seed and rind were found to be lower compared to the pumpkin pulp reported by Adebayo et al. [45]. Phytate in food can bind some essential mineral nutrients in the digestive tract and lead up to mineral deficiencies. Therefore, the low phytate content and nil detectable value in the pulp obtained from these samples suggest them to be good source of food to man with no potential harm in causing macronutrient deficiencies [33]. The values are in consonance with works done by most researchers in the *Curcubitaceae* family of plants, of which *C. lanatus* is among. The presence of phytate in the seed and rind of the plant can also contribute in the treatment of some ailments which respond to this bioactive ingredient. Phytate have been reported to offer nutritional benefits ranging from prevention of kidney stones [46,47] to protecting against diabetes mellitus [48] as well as a variety of cancers [49-51]. These findings show phytate to be healthful rather than largely anti-nutritional as against previous general opinions.

The flavonoid contents of the seed, pulp and rind were higher compared to that reported for *C. lanatus* in a previous study [43].

The seed, pulp and rind contained vitamins in varying amounts according to the present study. The pulp which is the more edible part contained the highest amount of vitamin A followed by the rind and seed. Vitamin A is a good antioxidant for the eyes and so makes the fruit a rich source of the vitamin. The seed, pulp and rind also contained vitamin C in significant amounts. These findings show that vitamin C is present in the fruit and explains why it is usually recommended in cases of scurvy and antioxidant stress following exposure to environmental stressors. The study also found Vitamin E to be present in the seed, pulp and rind at considerable values. These findings are also in support of previous work on potential medicinal possibilities of the seeds of *C. lanatus* [52].

The DPPH (1,1-diphenyl-2-picryl hydrazyl) free radical scavenging ability of the seed, pulp and rind of *C. lanatus* were also investigated and results indicated a range in activity from 30 to 60% with the seed having highest ability and the rind lowest. This is comparatively lower than the values of findings in previous related work [53]. The antioxidant activities of plant phytochemicals occur by preventing the production of free radicals or by neutralizing or scavenging free radicals produced in the body or reducing and chelating the transition metal composition of foods [54,55]. The prevention of the chain initiation step by scavenging various reactive species such as free radicals is considered to be an important antioxidant mode of action [56].

Results showed the activity of the seed, pulp and rind of *C. lanatus* on lipid peroxidation. The result observed that the inhibitory activity of the rind significantly increased at a concentration of 250  $\mu\text{g/ml}$ . However, as the concentration increased, the seed part showed the highest inhibitory activity when compared to the pulp and the rind. This is in agreement with the study conducted by Asita and Molise [57], which indicated that watermelon seed contained higher contents of carotenoids demonstrated to scavenge free radicals thus inhibiting lipid peroxidation. Lipid peroxidation can be defined as the oxidative deterioration of lipids containing carbon-carbon double bonds that yield a large number of toxic byproducts [58]. Membrane lipids are highly susceptible to peroxidation and free radical damage [59]. The highly damaging chain

reaction occurs as the lipids react with free radicals and this can lead to a production of various end products including malondialdehyde (MDA), the main carbonyl compound.

The reducing powers of the different parts of *C. lanatus* were assessed based on their ability to reduce Fe<sup>3+</sup> to Fe<sup>2+</sup>. The reducing power which is a novel antioxidation defense mechanism was determined by measuring the percentage iron chelation of the various parts of the *C. lanatus* and as was observed in this investigation, it showed the range of 0.15 to 0.35 with highest concentration in the seed and least in the rind. The content of reducing power observed in this work however, explains the medicinal importance and value of *C. lanatus* and this has been linked to the presence of phenolic compounds. Phenolic compounds have been reported to protect the human body from free radicals, whose formation is associated with the normal natural metabolism of aerobic cells. The antiradical activity of phenols is principally based on the structural relationship between different parts of their chemical structure [60]. Natural polyphenols are capable of removing free radicals, chelating metal catalysts, activating antioxidant enzymes, reducing α-tocopherol radicals and inhibiting oxidases [61]. However, the results obtained in this investigation are higher than that reported earlier for some Nigerian medicinal plants ranging from 0.06 to 0.81% [62]. The allusion however suggests the medicinal corollary of the fruit of *C. lanatus*.

## 5. CONCLUSION

This study indicates that *C. lanatus* is a good source of protein, fats, fiber, and essential minerals such as sodium, potassium, iron, phosphorus, zinc and calcium. The presence of pharmacologically essential phytochemicals in *C. lanatus* can synergize other dietary nutrients in protecting the body from certain disease conditions such as hyperlipidemia, hyperglycaemia etc. Comparatively, the fruit parts especially the rind have shown to be good dietary sources of vitamins possessing excellent antioxidant and anti-lipid peroxidative actions. This implies that the fruit parts can actually be made into some form of edible juices that can be consumed to supply the needed essential nutrients where the pulp alone cannot suffice with providing much of the nutrients. Research with respect to understanding the nutraceutical and biochemical role of the plant in certain

disease states is left to be unraveled as more scientific demands of the plant is required.

## ACKNOWLEDGEMENTS

The authors wish to acknowledge the Management of Springboard Laboratories for its thorough procedural analytical protocols involved in the outcome of the study.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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