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Proximate, Phytochemical and Vitamin Compositions of *Cucumis metuliferus* (Horned Melon) Rind

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Authors' contributions

This work was carried out in collaboration among all authors. Author ACE conceived the work, wrote the protocol and designed the study. Author AON managed the literature searches and wrote the first draft of the manuscript. Author OCK managed the analyses of the study and performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

Cucumis metuliferus also known as horned melon is a plant belonging to the *Cucurbitaceae* family which has been reported to have medicinal value. Every part of the plant is consumed, except the rind, although edible is mostly discarded as waste. Solid food waste contributes to greater percentage of pollution in our environment. Therefore, to minimize food wastage, the nutritional and medicinal value of the rind need to be evaluated to promote its usage. Hence, this study was aimed to investigate the proximate, phytochemical and vitamin compositions of the rind of *Cucumis metuliferus*. The analyses were carried out using standard methods. The proximate analyses showed that the rind contained high concentrations of carbohydrate (54.84%), moisture (18.40%) and crude fibre (11.34%); moderate concentration of crude fat (8.89%) with low concentration of ash (3.59%) and crude protein (2.95%). From the result of the phytochemical analysis, the rind contained varied concentrations of alkaloids, flavonoids, saponins, tannins, glycosides, terpenoids

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and phenol. The result also showed that the rind is rich in vitamins C, E, D, B9 and A with appreciable concentrations of vitamins B2, K, B1 and β-carotene which were all above the recommended daily vitamin allowance. The high concentration of these nutrients and phytochemicals proves that the rind of *Cucumis metuliferus* has nutritive and medicinal value. Therefore, the rind could be useful as food supplements and in pharmaceutical preparations.

Keywords: Cucumis metuliferus; horned melon; rind; proximate; phytochemical; vitamin.

1. INTRODUCTION

Throughout the world from ancient times, fruits and vegetables have always formed an important part of diet for both human and animals. Fruits and in general plants are sources of food to meet nutritional needs as well as serve medicinal and therapeutic purposes. In fact, almost every part of plants form the basis of traditional medicine system. Every part of fruits are eaten but generally, the outermost parts called rind or peel of most fruits are not eaten or used. These parts are unwanted and so are peeled off and thrown away as waste. With the increase in awareness for increased consumption of fruits and vegetables by international and national agencies [1], it is expected that more fruits will be produced and consumed [2]. This will result in increase in waste from the discarded parts of the fruits which contributes to environmental nuisance. However, good management of public health hazard arising from solid food waste could be achieved by prevention or minimizing the accumulation of these solid food wastes [3]. This could be done by efficient disposal and management or by increasing the utilization of these solid food waste in diet and food industries [3]. For dietary utilization, there is need to study the nutritional properties of these agricultural food wastes in order to provide scientific support for their potential use for diets and medicinal purposes; this is because peels of many fruits which are mostly discarded as wastes have been reported to possess rich natural bioactive constituents that can be employed in management of different disease conditions [4, 5]. More so, these food wastes can also lead to low cost of production in food industries and in addition create alternative functional foods for human consumption [6].

Cucumis metuliferus is a member of cucumber and melon family, Curcubitacea, a monoecious annual herb with staminate flowers that grow wild [7]. It is commonly called the horned melon, spiked melon, jelly melon, or kiwano. The fruit has horn-like spines and hence, the name "horned melon". Ripe fruit has orange skin and lime green, jelly-like flesh with a refreshingly fruity taste, and texture similar to a passion fruit or pomegranate and the unripe fruits are green [8-10]. It flowers and bear fruits from July to September and the fruits ripen from October to December [11]. The seeds and fruits are eaten raw and used for its anthelmintic properties [12]. Although the rind is edible, most people stick to eating the soft inner flesh which is full of seeds. *Cucumis metuliferus* is used in traditional medicine for different illnesses, for this reason it is expedient to analyze the different parts of the fruit for complete nutritional information. As there is no found documented or published reports on the nutritional, phytochemical and vitamin content of the fruit rind. This study was designed to ascertain the nutritive value of the fruit rind. This will stimulate interest in its dietary and therapeutic utilization, reduce wastage and could also be added to meet nutritional and therapeutic needs. Therefore, the aim of this study was to screen the rind of *Cucumis metuliferus* fruit for the presence of nutritive and phytochemical constituents for nutritional and medicinal benefits.

2. MATERIALS AND METHODS

2.1 Sample Collection and Identification

Cucumis metuliferus fruits were purchased from Gboko, Benue State, Nigeria. It was authenticated at Department of Applied Biology, Enugu State University of Science and Technology, Enugu, Nigeria.

2.2 Sample Preparation

Ten horned melon fruits were thoroughly washed with water to remove dirt. They were cut using kitchen knife. The pulp containing the seed was scooped out and the rind was retained. The rind was then cut into pieces and air-dried at room temperature for three weeks. The dried sample was ground into powder using mortar and pestle and subsequently into fine powder using an electric blender, sieved through muslin cloth. One hundred grams (100 g) of the powdered

sample was obtained and then kept in an air-tight container prior to analysis.

2.3 Proximate Analysis

Ash, crude fibre and moisture were determined according to the methods of AOAC [13]. Crude protein was determined using micro-Kjeldahl method. Carbohydrate was determined using difference method as reported by Onyeike et al [14]; % Carbohydrate = 100–(% moisture + %crude fibre + %ash + % crude fat + % crude protein).

2.4 Phytochemical Analysis

2.4.1 Qualitative phytochemical analysis

The qualitative phytochemical analysis was carried out in order to ascertain the presence of plant secondary metabolites. The determinations were done by utilizing standard conventional protocols as illustrated by [15,16]. The preliminary analysis involved testing for the presence of flavonoids, terpenoids, steroids, saponins, alkaloids, tannins, glycosides and phenols.

2.4.2 Determination of tannins

The sample (0.1 g) was stirred with 10 ml of distilled water and then filtered using Whatman no. 1 filter paper. Five drops of 1 % ferric chloride solution were added to 2 ml of the filtrate. The presence of a blue-black or blue-green precipitate indicated the presence of tannins [16].

2.4.3 Determination of alkaloids

This was determined according to the method of Trease and Evans [16]. A quantity of the sample (0.1 g) was dissolved in 10 ml of 1% dilute hydrochloric acid and filtered using Whatman no 1 filter paper. The filtrate was divided into four equal parts of 2.5ml each.

One part (2.5 ml) was analyzed using Mayer's Test: Filtrate was treated with Mayer's reagent (potassium mercuric iodide). Formation of a yellow coloured precipitate indicates the presence of alkaloids.

Another part (2.5 ml) was analyzed using Wagner's Test: Filtrate was treated with Wagner's reagent (iodine in potassium iodide). Formation of brown/reddish precipitate indicates the presence of alkaloids.

The third part (2.5 ml) was analyzed using Dragendroff's Test: Filtrate was treated with Dragendroff's reagent (solution of potassium bismuth iodide). Formation of red precipitate indicates the presence of alkaloids.

The last part (2.5 ml) was analyzed using Hager's Test: Filtrate was treated with Hager's reagent (saturated picric acid solution). Presence of alkaloids was confirmed by the formation of yellow coloured precipitate.

2.4.4 Determination of saponins

This was determined according to the method of Sofowara [17]. A quantity of the sample (0.1 g) was boiled with 5 ml of distilled water and filtered. To the filtrate, 3 ml of distilled water was further added and shaken vigorously for about 5 min. Frothing which persisted on warming was taken as an evidence for the presence of saponin.

2.4.5 Determination of glycosides

Glycosides were determined using the method of Sofowara [17]. The sample (0.1 g) was mixed with 30 ml of distilled water and heated on a water bath (70°C) for 5 minutes. To 5ml of the mixture, 0.2 ml of Fehling's solution A and B was added and it turned alkaline (tested with litmus paper). The solution was heated on a water bath (70^0C) for 2 min. A brick – red precipitate indicated the presence of glycoside.

2.4.6 Determination of terpenoids

This was determined using the method of Sofowara [17]. The sample (0.1 g) was dissolved in 10ml of 10% ethanol. Acetic anhydride (1 ml) was added, followed by the addition of 5 drops of concentrated H_2SO_4. A change in colour from pink to violet shows the presence of terpenoids.

2.4.7 Determination of flavonoids using lead ethanoate test

This was determined according to the method of Trease and Evans [16]. A quantity (0.1 g) of the sample was dissolved in distilled water and filtered. To 5 ml of the filtrate, 3 ml of lead ethanoate solution was added. Appearance of a buff – coloured (pale yellow-brown) precipitate indicates the presence of flavonoids.

2.4.8 Determination of steroids using liebermann-buchard test for steroids

This was determined according to the method of Sofowara [17]. To 0.1 g of the sample, 2 ml of acetic acid was added. The solution was cooled down in ice followed by the addition of 1ml concentrated tetraoxosulphate (VI) acid (H_2SO_4). Colour development from violet to blue or bluish-green indicates the presence of a steroidal ring.

2.4.9 Determination of phenol using ferric chloride test for phenols

This was determined according to the method of Trease and Evans [16]. About 0.1 g of the sample was boiled with distilled water and then filtered. To 2 ml of the filtrate, 6 drops of 10% ferric chloride solution were added. A green – blue or violet colouration indicated the presence of a phenolic hydroxyl group.

2.4.10 Quantitative phytochemical analysis

2.4.10.1 Determination of alkaloids using the method of Harborne [18]

A sample (1.0g) was weighed using electric weighing balance into a 250 ml glass beaker; 100 ml of 10% acetic acid in ethanol was added to the sample and covered. The mixture was allowed to stand for four hours for extraction to take place. The sample was filtered with Whatman no 1 filter paper and the extract was concentrated on a water bath (70°C) to one quarter of the original volume. 20 ml of ammonium hydroxide was added drop-wise to form precipitate of the alkaloid in the filtrate. The filtrate was washed with 20 ml of 0.1 M NH_4OH and then filtered with Whatman no 1 filter paper. The filter paper was weighed before using it to filter. After filtering, the filter paper and the precipitate was dried in an oven at 40°C and weighed. The alkaloid content was determined using the following formula.

$$\text{Concentration of alkaloids} = \frac{W2 - W1}{W3}$$

Where;

W1 = weight of filter paper
W2 = weight of the alkaloid and filter paper
W3 = weight of sample

2.4.11 Determinations of saponins

This was done using the method of Obdoni and Ochuko [19]. The sample (1.0 g) was weighed using an electric weighing balance into a 250 ml conical flask and soaked in 100 ml of 20% ethanol for three (3) min and heated for three (3) hours at 55°C for extraction then filtered. The residue was re-extracted with additional 100 ml of 20% ethanol. The two samples were combined, heated and reduced to 40 ml at 90°C in a water bath. The concentrate was transferred into a 500 ml separating funnel and 20 ml of diethylether was added and shaken vigorously, The upper layer was discarded. The purification process was repeated three times and 60 ml of n-batanol was added. The combined n-butanol mixture was washed twice with 10 ml of 5% aqueous NaCl and the lower layer was discarded while the upper layer was collected in a weighed beaker and heated to a constant weight. The beaker was allowed to cool in a desiccator and re-weighed. The saponin content was determined using the following formula.

$$\text{Concentration of saponins} = \frac{W2 - W1}{W3}$$

Where;

W1 = weight of empty beaker
W2 = weight of beaker + sample after heating
W3 = weight of sample

2.4.12 Determination of tannins using the method of Van-burden and Robinson [20]

A sample was weighed (1.0 g) into a plastic bottle and 50 ml of distilled water was added and shaken for 3 hours in a vibrator. The sample was filtered into a 50 ml volumetric flask and made up to mark. 5 ml of the filtrate was dispensed into a test tube and mixed with 2 ml of 0.1M FeCl2 in 0.1N HCl and 0.008 M potassium ferrocyanide. The absorbance was measured at 120 nm for 10 mins. The tannin concentration was determined using the following relation.

$$\text{Concentration of tannin} = \frac{\text{Abs} \times \text{D.F}}{1000 \times \text{weight of sample used}}$$

Where;

Abs = value of absorbance read
D.F = dilution factor

2.4.13 Determination of flavonoids using the method of Bohn and Kocipal-Abyassan [21]

A sample (1.0 g) was repeatedly (three times) extracted with 100 ml of 80% aqueous methanol

at room temperature; the solution was shaken for 30 min and filtered using Whatman no 1 filter paper. The filtrate was transferred into a weighed beaker and evaporated to dryness over a water bath and weighed again. The time of the first extraction was 1 hour, 45 min for the second extraction and 30 mins for the third extraction. Flavonoids were determined using the following formula.

$$\text{Concentration of flavonoids} = \frac{\text{W2} - \text{W1}}{\text{W3}}$$

Where;

W1 = weight of empty beaker
W2 = weight of beaker + sample after drying
W3 = weight of sample

2.4.14 Determination of steroids using the method of Okeke and Elekwa [22]

A sample (1.0 g) was dispersed in 100 ml of distilled water into a conical flask, the mixture was shaken for 3 hours and allowed to stand overnight. It was filtered and the filtrate was eluted with 10 ml normal ammonium hydroxide solution, 2 ml of the elute was put into a test tube and mixed with 2ml of chloroform. Additionally, 3 ml of acetic hydride was also added to the mixture, followed by 2 ml of concentrated H_2SO_4 drop-wise. The absorbance was measured at 420 nm using a Spectrophotometer at 420 nm.

The steroid concentration was determined using the following relationship

$$\text{Concentration of steroids} = \frac{\text{Abs} \times \text{Path length}}{100 \times \text{Weight of sample}}$$

2.4.15 Determination of Terpenoid content

The determination of terpenoids were carried out according to the method of Harborne [18]. A quantity (0.1 g) of the sample was weighed out, macerated with 20 ml of ethanol and filtered through Whatman No. 1 filter paper. The filtrate (1 ml) was pipetted out and 1 ml of 5% phosphomolybdic acid solution was added and shaken. Gradually 1 ml of concentrated H_2SO_4 was added. The mixture was left to stand for 30 min. Ethanol (2 ml) was added and absorbance was measured at 700 nm.

$$\text{Concentration of terpenoids} = \frac{\text{Abs} \times \text{Path length}}{100 \times \text{weight of sample}}$$

2.4.16 Determination of glycoside content

The determination of glycosides were carried out according to the method of Harborne [18]. A sample (0.1 g) was weighed out, macerated with 20 ml of distilled water and 2.5 ml of 15% lead acetate was added and filtered. Chloroform (2.5 ml) was added to the filtrate, shaked vigorously and the lower layer collected and evaporated to dryness. Glacial acetic acid (3 ml) was added together with 0.1 ml of 5% ferric chloride and 0.25 ml of concentrated H_2SO_4. The mixture was shaken and put in the dark for 2 hours. Absorbance was measured at 530 nm.

$$\text{Concentration of glycoside} = \frac{\text{Abs} \times \text{Path length}}{100 \times \text{weight of sample}}$$

2.5 Vitamin Analysis

The vitamin contents were determined using the modified method of AOAC [23].

2.5.1 Determination of vitamin A concentration

One gram of sample was macerated with 200 ml of petroleum ether for 10 min, and allowed to stand for 1 hour with intermittent shaking at every 1 min. The mixture was centrifuged for 5 min and 3 ml of the supernatant was transferred into three separate test tubes. Each supernatant in the test tube was evaporated to dryness and the residue re-dissolved with 0.2 ml of acetic anhydride/chloroform (1:1) and 2 ml of 50% trichloroacetic acid (TCA) in chloroform. The absorbance of the resulting solution was measured at 620 nm at 15 seconds and again after 30 seconds against a blank (mixture without the sample).

2.5.2 Determination of beta carotene concentration

A Sample (5 g) was weighed into a test tube and 20 ml of petroleum ether was added and shaken for 5 min. The supernatant was decanted into another test-tube and the absorbance was read at 450 nm.

2.5.3 Determination of vitamin C concentration

One gram of the sample was macerated with 20 ml of 0.4% oxalic acid for 10 min and centrifuged at 3000rpm for 5 min. The supernatant (1 ml) was transferred into test tubes and 9 ml of 2, 6-

dichlorophenol indophenols (12 mg/l) was added, shaken and mixed thoroughly. The absorbance of the resulting solution was read at 520 nm after 15 sec and again after 30 sec against corresponding blank (mixture without sample).

2.5.4 Determination of vitamin E concentration

One gram of the sample was macerated with 20 ml of petroleum ether for 10 min and allowed to stand for 1 hour with intermittent shaking at every 1 min, and centrifuged at 3000rpm for 5 mins. The supernatant (3 ml) was transferred into three separate test tubes, evaporated to dryness and the residue re-dissolved with 2 ml of 10% ethanol and shaken. A volume (1 ml) of 0.2% ferric chloride in ethanol and 1 ml of 0.5% α-dipyridyl in ethanol were added to the resulting solution and made up to 5 ml with ethanol. The mixture was thoroughly shaken and the absorbance read at 520 nm against a corresponding blank (mixture without the sample).

2.5.5 Determination of vitamin B1 (Thiamine) concentration

One gram of sample was homogenized with 50 ml of ethanolic sodium hydroxide solution and filtered into a 100 ml flask. Filtrate (10 ml) was pipette into a beaker and 10 ml potassium dichromate added for color development. A blank sample (mixture without the sample) was prepared and the absorbance was taken at 560 nm. The concentration of each sample was extrapolated from a standard calibration curve.

2.5.6 Determination of vitamin B2 (Riboflavin) concentration

The sample (5 g) was extracted with 100 ml of 50% hydrogen peroxide and allowed to stand for 30 min. Thereafter, 2 ml of 40% sodium sulphate was added to makeup to 50 ml mark. The absorbance was read at 510 nm was using a spectrophotometer.

2.5.7 Determination of vitamin B9 (Folic acid) concentration

One gram of the sample was weighed into a beaker and extracted with 100 ml of distilled water in a water bath slightly at 70°C. The mixture was shaken thoroughly and filtered after cooling. The absorbance of the filtrate was read spectrophotometrically at 325 nm.

2.5.8 Determination of vitamin D concentration

One gram of the sample was weighed into a beaker and macerated with 20 ml 10% ethanol for 10 min and filtered using Whatman no 1 filter paper. Thereafter, 0.5 ml of 50% sulphuric acid was added to the filtrate over a period of 1 min and diluted to 2.5 ml with 10% ethanol. Then, another 1 ml of 50% sulphuric acid was added over a period of 1 min and mixed thoroughly. The absorbance was read after 2 min at 525 nm.

2.5.9 Determination of vitamin K concentration

One gram of the sample was dissolved in 10 ml of distilled water and filtered using Whatman no 1 filter paper. To 1 ml of the filtrate, 2 ml of distilled water and 1 ml of 0.2% hydrochloric acid were added. The mixture was heated in boiling water for 45 min and cooled down. The mixture was then diluted with 10 ml 33% ammonium hydroxide and the absorbance of the mixture was read at 635 nm against a blank (mixture without the sample).

2.6 Statistical Analysis

Data was analyzed using analysis of variance (ANOVA). Results were expressed as mean ± standard deviation (SD) of duplicate determinations.

3. RESULTS

3.1 Proximate Composition

The result of the proximate composition is shown in Table 1. From the result, carbohydrates were the predominant component followed by moisture. Protein was the lowest.

3.2 Phytochemical Content

Table 2 shows the result of the quantitative and qualitative phytochemical screening of the rind of *Cucumis metuliferus*. Glycosides was above 2 mg/g, while flavonoids, phenols and tannins were above 1 mg/g. Saponins, steroids and terpenoids were below 1 mg/g.

3.3 Vitamin Content

The result of the vitamin content is presented in Table 3. Vitamin C was the highest while β-carotene was the lowest.

Table 1. Proximate composition of the rind of *Cucumis metuliferus*

Proximate content	Composition (%)
Moisture content	18.40 ± 0.49
Ash content	3.59 ± 0.51
Crude fat	8.89 ± 0.46
Crude fibre	11.34 ± 0.13
Crude protein	2.95 ± 0.23
Carbohydrates	54.84 ± 0.90

Values are mean ± standard deviation of duplicate results

Table 2. Quantitative and qualitative phytochemical composition of the rind of *Cucumis metuliferus*

Phytochemical	Quantitative composition (mg/g)	Qualitative composition
Alkaloids	1.06 ± 0.19	+
Flavonoids	1.71 ± 0.04	++
Saponins	0.72 ± 0.05	+
Steroids	0.93 ± 0.01	+
Tannins	1.38 ± 0.05	++
Glycosides	2.19 ± 0.10	+++
Terpenoids	0.82 ± 0.03	+
Phenols	1.54 ± 0.13	++

Key: +++ (highly present); ++ (moderately present); + (present in trace concentrations)

4. DISCUSSION

Cucumis metuliferus also known as horned melon is a widely consumed fruit in Nigeria especially at the northern part. The rind is although edible but it is usually discarded as food waste and so constitute environmental pollution. This study was carried out to provide an insight into the nutritional and phytochemical composition of horned melon rind.

The results of the proximate analysis in Table 1 show that the rind contained high concentrations of nutrients such as carbohydrates, crude fibre and crude fat with low concentrations of crude protein and ash. The high carbohydrate concentration of the rind could provide energy to human. The crude fibre content will aid in digestion as fibre helps in bowel movement. Fibre containing foods are known to enlarge the inside walls of the colon, easing the passage of waste, thus making it an effective laxative [24]. It reduces blood cholesterol and lowers the risk of various cancers. However, it has been emphasized that the intake of excessive fibre should be kept low in diet of infants and weaning children because high level of fibre can lead to irritation of the gut mucosa [25]. It also enhances gut perturbation in young animals such as piglets and chickens [26]. High moisture content of the rind shows that the rind does not have a long shelf life and could be susceptible to microbial attack if stored for long. The crude fat content (8.89 mg/g) was high as there is a general belief that vegetables and fruits are low fat containing foods. The value obtained is higher than that of peels of most fruits in the same family such as Cucumis sativus with crude fat content of 1.44% as reported by Oluwagbenle et al. [27]. This high crude fat value is beneficial it provides energy for the human body [28]. However, it could be considered to be in excess as a diet that provides more than 1–2% of its caloric energy as fat could lead to cardiovascular disorders [29]. The low concentration of protein shows that the rind may not be a good source of protein. The ash content was also low. Ash is an index of the mineral content of food. These minerals such as calcium, zinc and magnesium play a role of inorganic co-factors in macronutrient metabolism and so low levels of these inorganic co-factors could lead to metabolic impairment [27]. The overall result from the proximate analysis showed that *Cucumis metuliferus* rind can be used as a food supplement in meeting nutritional needs and serve as a source of energy.

The results of the quantitative and qualitative screening of phytochemical constituents of *Cucumis metuliferus* rind indicated the presence of alkaloids, flavonoids, saponins, steroids, tannins, glycosides, terpenoids and phenols. The values obtained are higher than that reported on the rind of watermelon [3,6]. Phytochemicals are

Table 3. Vitamin content of the rind of *Cucumis metuliferus*

Vitamins	Concentration (mg/g)
Vitamin A	1.85 ± 0.17
B-Carotene	1.29 ± 0.08
Vitamin B1	1.69 ± 0.08
Vitamin B2	1.74 ± 0.01
Vitamin B9	1.93 ± 0.06
Vitamin C	3.44 ± 0.10
Vitamin D	2.28 ± 0.06
Vitamin E	2.92 ± 0.01
Vitamin K	1.69 ± 0.06

Values are mean ± standard deviation of duplicate results

important bioactive compounds that play protective and therapeutic roles. Alkaloids and saponins have antimicrobial activities. Alkaloids exhibit antibacterial and antifungal properties in plants and ensuring their survival against micro-organisms, insects and herbivores as well as against other plants by means of allopathically active chemicals [30]. Saponins inhibit growth of moulds and are known to be antimicrobial and protects plants from insect attack acting as part of the plants' defense systems, and belong to a group called phytoanticipins or phytoprotectants, which are protective molecules found in plants [31]. Flavonoids and phenols are important secondary metabolites with antioxidant activity and act as free radical scavengers [32]. Tannins are polyphenols with an ability to inhibit proliferation of bacterial cell wall through hindering essential enzymes of microbial metabolism such as proteolytic macerating enzymes [33]. It is also shown that tannin-containing plant extracts are used for treatment of diarrhea, as astringents, as diuretics in stomach and duodenal tumours, and as anti-inflammatory, antiseptic, antioxidant and haemostatic pharmaceuticals [34]. Cyanogenic glycosides containing plant extracts are used in pharmaceutical preparations as flavouring agents [35]. Therefore, the content of glycosides (2.19mg/g) in the rind of *Cucumis metuliferus* makes it a potential flavouring agent in pharmaceutical preparations. Plant steroids are phytoconstituents that are used in therapy as arrow poisons or cardiac drugs [36]. The concentration of steroid found in the rind (0.93 mg/g) is sufficient and could be used in promoting nitrogen retention in osteoporosis and in animals with wasting illness [37,38]. The presence of terpenoids in the rind could be useful in the management and treatment of malaria, ulcer and cancer as terpenoids have been reported to possess medicinal activities such as anti-carcinogenic, antimalarial, anti-ulcer, antimicrobial and diuretic activity [39]. Plants produce volatile terpenes either to attract specific insects for pollination or repel certain preys which eat these plants [40]. The overall results of the phytochemical screening show that the rind of *Cucumis metuliferus* is rich in phytoconstituents and possess medicinal properties with potentials to act as antibacterial, anti-cancer, antifungal and anti-inflammatory agent.

Vitamins are essential, but are required in low quantities for the regulation of normal metabolism and as antioxidants [41]. The results in Table 3 show that vitamin C was highest the rind of *Cucumis metuliferus* followed by the fat-soluble vitamins i.e. vitamin A, D, E and K). Vitamin A is essential for vision and β-carotene (a member of carotenoids family and precursor of biologically active molecules of vitamin A such as retinal) is an effective antioxidant. Vitamins C and E are essential antioxidants that protect the cells from oxidative damage by reactive oxygen species [42]. In addition, vitamin C is needed for wound healing, maintenance of connective tissues and enhances the absorption of dietary iron from the intestine [43]. Vitamin K plays an important role in blood coagulation. The concentration of vitamin K (1.69mg/g) obtained from this study is higher than the recommended daily allowance (RDA) of 70 to 140µg for an adult [44]. The fat-soluble vitamins are important in lipid metabolism, while the water-soluble vitamins (B vitamins) participates in various metabolic processes. Thiamine (Vit. B1) and folic acid (Vit. B9) serve as coenzymes in synthetic and metabolic processes. Values of 1.69 and 1.93 mg/g obtained in this study are slightly higher than the recommended daily allowance of 1.5 mg and 0.2 mg respectively. Riboflavin (Vit. B2) is essential for oxidative phosphorylation [45]. The concentration of vitamin B2 obtained was 1.74 mg/g and this is also slightly higher than the RDA range of 1.3 to 1.7 mg for adults. From the result

obtained, the rind of *Cucumis metuliferus* can meet the daily vitamin requirement and could be a source of antioxidants which is needed to protect cells from deleterious effects of free radicals. Deficiencies of these vitamins predispose the red cell membranes to damage leading to haemolysis [45].

5. CONCLUSION

From this study it was shown that the rind of *Cucumis metuliferus* can serve as a source of nutrients which can be used to meet the nutritional needs of man and animals. The high phytoconstituents and vitamin contents make it a potential source of therapeutic compounds which can be rightly applied for medicinal purposes. The findings from this study will create awareness on the nutritional and medicinal benefits associated with the use of this rind extract and thereby reduce production of solid food waste which can cause environmental hazards. In view of this, long term toxicity studies are required to ascertain its safety.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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