Nig. J. Pure & Appl. Sci. Vol. 38 (Issue 1, 2025)
e-ISSN 2756-4045
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www.njpas.com.ng

Nutritional Evaluation of Aqueous Extract of *Citrullus lanatus* var. citroides (Watermelon) Rinds

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Date Received: 01-07-2024
Date Accepted: 21-10-2024
DOI: https://doi.org/10.48198/NJPAS/24.B13

ABSTRACT

There is an increased consumption of *Citrullus lanatus* (watermelon) rinds among various communities in the Northwestern region of Nigeria presently. This has prompted a nutritional evaluation of its proximate composition, phytochemicals and antioxidant vitamins content to elucidate its nutritional and therapeutic potentials. This study, therefore, focuses on assessing these parameters from the aqueous extract of *C. lanatus* rind. The rinds were collected, dried and subjected to extraction using distilled water. Standard methods were employed for the various analyses. Proximate analysis of *C. lanatus* rind indicated moisture content, ash content, crude protein, crude lipid, crude fibre and carbohydrate as 6.40 ± 0.005 %, 3.43 ± 0.008 %, 10.87 ± 0.040 %, 1.29 ± 0.005 %, 25.71 ± 0.005 %, and 50.04 ± 0.056 %, respectively. The qualitative analysis indicated the presence of phytochemicals, such as Flavonoids, Tannins, Saponins, Glycosides, Alkaloids, Steroids, Cardiac glycosides, Saponin glycosides, and Volatile oils. Quantitatively, the analysis of phytochemicals revealed concentrations (in g%) of 14.45±0.03, 5.64±0.42, 1.69±0.07, 0.07±0.01, 2.30±0.01, 0.04±0.00 for Flavonoids, Tannins, Saponins, Glycosides, Alkaloids and Steroids, respectively. The *C. lanatus* rind extract also showed significant levels of antioxidant vitamins; A, E and C (mg/dl) as 67.87±0.98, 143.45±1.98 and 37.08±5.69, respectively. These results suggest the substantial content of essential nutrients, bioactive compounds and antioxidant vitamins in *C. lanatus* rind, indicating its potential use as a dietary supplement to address protein-energy deficiencies and as a therapeutic agent.

Keywords: *Citrullus lanatus*, rind, proximate composition, phytochemicals, antioxidants.

Introduction

The use of plants for nutritional and medicinal purposes predates recorded homo sapiens' history. Many herbs and spices used to season foods since ancient times contain valuable bioactive and medicinal compounds (Ajuru *et al*., 2017). The nourishing and healing properties of these plants often stem from specific groups of bioactive chemicals. These chemicals, including alkaloids, terpenoids, flavonoids, plant sterols, and polyphenols, vary widely in their structures and functions, and contribute significantly to the bioactivities found in many plants (Vasanthi *et al*., 2012). Following the increasing incidences of chronic ailments in the world currently, the World Health Organization (WHO) encourages

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especially developing countries to explore traditional plants-based medications for treatment of various chronic diseases (Vasanthi *et al*., 2012).

Citrullus lanatus (Watermelon) originates from Africa, within the Cucurbitaceae family (Ijaz *et al*., 2022). This fruit is a summer staple, consumed in many regions of the world, like apples and bananas (Maheshwari *et al*., 2022). *C. lanatus* fruit, enjoyed for its succulent taste and high-water content, is rich in essential nutrients such as carbohydrates, minerals, such as potassium and magnesium as well as vitamins, including vitamins A, B, and C, and other antioxidant compounds, such as lycopene and phenolic compounds (Asfaw, 2022). Interestingly, *C. lanatus* seeds and rinds, often overlooked, is reported to contain high amounts of beneficial nutrients and bioactive compounds (Athanasiadis *et al*., 2023). The bioactive compounds, such as citrulline and cucurbitacin E in *C. lanatus* fruit contribute to essential health benefits, including vasodilation, antioxidative properties, and anti-inflammatory effects (Ijaz *et al*., 2022). Numerous studies have extensively identified *C. lanatus* plant's genetic diversity and breeding and resulted in many varieties of the plant with improved characteristics (Mashilo *et al*., 2022).

There is an increased consumption of *C. lanatus* rind in several communities in Northwestern Nigeria, which was hitherto, overlooked and thrown away as garbage. This trend prompted the need to evaluate its nutritional and therapeutic relevance due to paucity of literature on the *C. lanatus* rinds. The outcome of this research, therefore, could lend credence to the use of *C. lanatus* rinds in improved food applications and drugs development.

Materials and Methods

Sample Collection and Preparation

The *C. lanatus* rinds were collected from the popular Sokoto fruits market called "kasuwar daji". The rinds were dried under shade at room temperature in the Biochemistry department's laboratory, Usmanu Danfodio University Sokoto. The dried rinds were pulverized into powder using mortar and pestle, sieved into a very fine powder and then stored in clean polythene bags, until required for the analyses.

Sample Extraction from Citrullus lanatus Rinds

Exactly 5g of the powdered sample of *C. lanatus* rinds was measured into a conical flask and 100ml of distilled water added to it and allowed to stand for 1 hour at room temperature, after which it was then filtered using the Whatman filter paper. The aliquot obtained was utilized in conducting the various experiments.

Proximate Composition Analysis of the C. lanatus rinds

Determination of Moisture Contents

The determination of moisture content was based on the principle of heating biologically active material under controlled conditions. The sample is placed in an oven set at 105°C for 24 hours, during which the water content evaporates, leaving behind the dry matter. The weight difference before and after heating provides the moisture content of the substance (AOAC 1999). The empty petri dish was weighed and recorded as W_1. Then 2g of the sample were weighed and added to the empty petri dish to obtain W_2. The petri dish with the sample was placed in the oven at 105°C for 24 hours. After 24 hours, the petri dish with the sample was weighed to obtain W_3. The percentage moisture was then calculated using the formular:

$$\% \text{ Moisture} = \frac{W3 - W1}{W2} \text{ X } 100$$

Determination of Ash Content

The ash content of the sample was determined by measuring the residue left after the sample undergoes high-temperature incineration. This method operates on the principle that organic

components in the sample are oxidized and vaporized at elevated temperatures, leaving behind only inorganic minerals as ash (Chukwuneke *et al.*, 2020). Initially, the empty crucible was weighed and recorded as W_1. Next, 2g of the sample were added to the crucible reweighed and recorded as W_2. The crucible containing the sample was then placed in a muffle furnace at 600°C for 5 hours. After cooling in a desiccator, the crucible together with the residue were weighed and recorded as W_3. The percentage ash content was calculated using the formula:

$$\% \text{ Ash} = \frac{W3 - W1}{W2} \text{ X } 100$$

Determination of Crude Protein

This method involves the oxidation of protein with sulfuric acid (H_2SO_4) and the reduction of nitrogenous compounds to ammonium sulfate. The acid is neutralized when an excess amount of sodium hydroxide (NaOH) is added in a closed system, thereby releasing ammonium which is then diluted into a boric acid solution and titrated against 0.1N hydrochloric acid to the endpoint (Kjeldahl, 1883). In the digestion process using a micro Kjeldahl flask, 0.4 g sample was placed into the flask. A catalyst, 0.6g of selenium tablet, was added, followed by 10 ml of H_2SO_4. The flask is then heated in a fume hood until digestion was complete, indicated by a clear solution or color change. After cooling, the mixture in the flask was made up to the volume of to 50 ml with distilled water. Next, 10 ml of the solution was transferred into a conical flask, and 20 ml of boric acid (used as an indicator) was added and positioned under the condenser. The solution underwent distillation, and then 10 ml of the resulting distillate (aliquot) and 20 ml of NaOH were measured and added back to the Kjeldahl flask, which was heated. For titration, 0.01 ml increments of HCl were titrated against the distillate until a color changed which indicated the endpoint. The initial and the final burette readings were recorded, and percentage crude protein was calculated as:

$$\% \text{ Nitrogen (\%N)} = \frac{\text{Tv X } 0.014 \text{ X } 0.01 \text{ X } 50}{0.5 \text{ X } 10} \text{ X } 100$$

Where NA (normality of acid) = 0.01N; DF (dilution factor) = 0.014; TV= titer value.

Volume of solution (aliquot) = 10ml; Volume of mixture = 50ml; Weight of sample = 0.5g

% Crude protein = % N x 6.25 (Conversion factor).

Determination of Crude Lipids

The content of crude lipid in the sample was determined by extracting the lipid fraction using a solvent, followed by evaporating the solvent to isolate the lipid residue. This method relied on the solubility of lipids in organic solvents, allowing them to be separated from the sample (Meier *et al*., 2000). The weight of the empty flask was measure and recorded as W_1. Then, 2g of the sample were weighed and placed into the flask and was recorded as W_2. The setup, including the heater, flask, and condenser, were arranged, and the solvent along with the sample were poured into the flask. The mixture was heated for 6 hours to extract the oil. After cooling, the flask containing the extracted lipid was weighed and recorded as W_3. The measurement of W_3 was done in triplicates for other outcomes. The percentage lipid extracted was calculated as:

$$\%\text{Lipid} = \frac{W3 - W1}{W2} \text{ X } 100$$

Determination of Crude Fiber

This method involves sequentially digesting the biological material with alkaline and acidic solutions. Initially, 2g sample (W_3) was placed into a beaker. Then, 20 ml of 10% Sulfuric acid (H_2SO_4) were added, then the mixture was boiled for 30 minutes. After boiling, the mixture was filtered, and the residue was washed with distilled water. The residue was then transferred into another beaker, and 20 ml of 10% Sodium

hydroxide (NaOH) were added. The mixture was boiled for another 30 mins and then filtered. The residue was washed with distilled water, followed by methanol, and then transferred into a crucible. The crucible containing the residue underwent drying at 105°C. After drying, the crucible was weighed and recorded as W_1. Subsequently, the crucible containing the residue was placed into the muffle furnace and heated to 550°C. After cooling, the crucible with the residue was reweighed and recorded as W_2. The percentage of the crude fiber was then calculated as:

$$\% \text{ Crude fiber} = \frac{W3 - W1}{W2} \times 100$$

Qualitative Analysis of Phytochemicals of the Aqueous Extract of C. lanatus rinds

Test for Flavonoids

Exactly 1ml of 10% NaOH was added to 3ml of the filtrate in a test tube. The presence of yellow coloration indicated the presence of flavonoids (El-Oleyi *et al*., 1994).

Test for Saponins

Exactly 5ml distilled water was added to 5ml extract in a test tube, vigorously shaken, and observed for the formation of persistent froth, indicating the presence of saponins (Harbone, 1973).

Test for Tannins

Exactly 2ml of 5% Ferric chloride solution was mixed with 2ml extract. The development of blue-black coloration indicates hydrolysable tannins, while dark-green coloration indicates condensed tannins (Trease and Evans, 1978).

Test for Alkaloids

To 2ml of the extract, 2ml of 10% HCl was added. Separate 1ml portions were treated with Mayer's reagent and Wagner's reagent. The appearance of precipitation or turbidity with either reagent suggests the presence of alkaloids (Harbone, 1973).

Test for Anthraquinones

Accurately 10ml of benzene solution was added to 5ml extract in a test tube and shaken. This was followed by addition of 5ml of 10% Ammonia solution and shaken again. The appearance of violet, pink or red color in the ammoniacal phase confirms the presence of anthraquinones (Smith *et al*., 2010).

Test for Cardiac Glycosides

In a test tube containing 0.5ml of the extract, 2ml of 3.5% Ferric chloride solution was added and allowed to stand. Then, 2ml H_2SO_4 was carefully added along the tube's wall, forming a layer. The presence of reddish-brown colour indicates the presence of cardiac glycosides (Levine, 2017; Hui, 2008).

Test for Saponin Glycosides

Exactly 2.5ml Fehling's solutions A and B were added to 2.5ml extract in a test tube. The formation of a bluish-green precipitate suggests the presence of saponin glycosides (El-Oleyi *et al*., 1994).

Test for Balsams

A volume of 2ml 90% ethanol was added to 2ml extract, followed by the addition of 2 drops of chloride solution. The appearance of a dark green colour signifies the presence of balsams (El-Oleyi *et al*., 1994).

Test for Volatile Oils

For volatile oils, 1ml of the extract was mixed with equal volume of dilute HCl. The formation of white precipitate indicates the presence of volatile oils (Evans, 1980).

Test for Steroids

In a test tube with 2ml chloroform solution and 2ml extract, 2ml H_2SO_4 was gently added to form a lower layer. The formation of a reddish-brown

color at the interface indicates the presence of steroid ring (Harbone, 1973).

Test for Glycosides

To 5ml of the extract in a test tube, 2.5ml of 50% H_2SO_4 was added. The mixture was heated for 15 minutes in boiling water, cooled, and neutralized with 3ml of 10% NaOH. After adding 5ml of Fehling's solution and boiling again, the appearance of a brick-red precipitate confirms the presence of glycosides (Harbone, 1973).

Quantitative Phytochemical Analysis of the C. lanatus rinds

Determination of Alkaloids

Alkaloid-free bases are soluble in organic solvents, while their salts dissolve in water. Organic solvents are therefore, used to extract alkaloid-free bases. Exactly 5g of powdered sample was measured into a 200ml beaker, and 200ml of 20% acetic acid was added. The mixture stood for 4 hours, then filtered. The extract was concentrated to 1/4 of its original volume using a water bath. Then concentrated ammonia solution was added to the extract dropwise until precipitation was complete. After allowing the solution to settle, the precipitate was collected by filtration using weighed filter paper (Harbone, 1973).

$$\% \text{ Alkaloids} = \frac{W3-W1}{W2} \text{ X } 100$$

Determination of Flavonoids

Flavonoids were quantified using the precipitation method described by Boham and Kocipai (1974). In a 250ml conical flask, 5g of powdered sample was hydrolyzed by boiling in 100ml of HCl solution for 30 minutes. The hydrolysate was filtered to recover the filtrate. Ethyl acetate was then added to the filtrate until in excess. After drying in an oven at 100°C for 30 minutes, the precipitated flavonoids were collected by filtration using weighed filter paper. The filter paper with precipitate was cooled and reweighed. The weight difference represented the percentage of flavonoids in the sample analyzed (Boham and Kocipai, 1974).

$$\% \text{ Flavonoids} = \frac{W3-W1}{W2} \text{ X } 100$$

Determination of Steroids

Steroids are a group of fat-soluble compounds widely found in plants with diverse biological properties. In a 100ml volumetric flask, 0.1g of powdered sample was mixed with 10ml of 100% methanol. The mixture was allowed to stand for 60 minutes, and then filtered using Whatman filter paper in a 100ml beaker. Three test tubes were arranged and labeled as blank, standard, and test. The blank tube received 1ml of distilled water, the standard tube received 1ml of standard reagent, and the test tube received 1ml of the extract. To each tube, 2ml of 0.5% $FeCl_3$, 2ml of 4N H_2SO_4, and 0.5ml of potassium hexacyanoferrate were added sequentially. The solutions were mixed, boiled at 60°C for 20 minutes, then cooled. The absorbance of the samples and the standard were measured spectrophotometrically at 780nm (Harbone, 1973). Steroid concentrations were determined using the following formula:

$$\text{Concentration of steroids} = \frac{\text{Absorbance of Sample X Concentration of standard}}{\text{Absorbance of standard}}$$

Determination of Tannins

The tannins and pseudo-tannins were quantitatively determined by their reaction with iodine, which correlates with their phenolic nature. True tannins can be selectively precipitated from the extract using gelatin, distinguishing them from pseudo-tannins. Excess iodine was titrated with a standard solution of sodium thiosulfate to determine its concentration. In a 100ml conical flask, 100mg of powdered sample was combined with 50ml distilled water and boiled for 30 minutes in a water bath, followed by filtration through filter paper. Three test tubes were

prepared and labeled as blank, standard, and test. The blank tube received 10ml of distilled water, the standard tube received 10ml of standard tannic solution, and the test tube received 10ml of the extract. To each tube, 10ml of 17% sodium carbonate and 2.5ml of fill-in Dennis reagent were added. The volume was made to 50ml with the distilled water and incubated for 20 minutes at room temperature. Absorbance was then measured and recorded at 760nm (Trease and Evans, 1978).

$$\text{Tannins} = \frac{\text{Absorbance of Sample X Concentration of standard}}{\text{Absorbance of standard}}$$

Determination of Glycosides

The glycosides in a sample hydrolyze into aglycone and sugar components under specific conditions. The concentration of glycosides can be determined by analyzing the aglycone using techniques such as chromatography or spectrophotometry. For the analysis, 1g of powdered sample was mixed with 10ml of 70% alcohol and filtered. To precipitate resins, tannins, and pigments, 8ml of the filtrate was combined with 8ml of 12.5% lead acetate, shaken thoroughly, diluted to 10ml with distilled water, and filtered. Then, 50ml of the filtrate was transferred to another 100ml volumetric flask, where 8ml of 4.7% disodium hydrogen phosphate (Na_2HPO_4) solution was added to precipitate excess lead. The volume was made up to 100ml with distilled water, mixed, and filtered twice through filter paper. For color development, a blank sample of 10ml distilled water was mixed with 10ml of Ballet's reagent and allowed to stand for one hour. The spectrophotometer was zeroed using a blank of 20ml distilled water, and the intensity of the resulting color was measured and recorded at 495nm (El-Olemy *et al*., 1994).

$$\% \text{ Glycosides} = \frac{\text{A X 100 g\%}}{17}$$

Where A is the absorbance of the test sample at 495nm.

Determination of Saponins

Saponins, which are soluble in water or boiling dilute alcohol, can be precipitated by acetone (El-Olemy *et al*., 1994). In a 250ml conical flask, 100ml of 50% alcohol were mixed with 5g of powdered sample. The mixture was refluxed for 30 minutes, then immediately filtered through coarse filter paper. To this filtrate, 2g of charcoal were added, boiled again, and filtered while hot. The resulting extract was cooled, and saponins were precipitated by dissolving in boiling 95% alcohol and filtering while hot to remove insoluble matter. Upon cooling to room temperature, saponins precipitated out, were collected, and suspended in approximately 20ml of alcohol, then filtered to obtain the filtrate. The filter paper containing saponins was transferred promptly to a desiccator with anhydrous calcium chloride, allowing the saponins to dry and be weighed.

$$\% \text{ Saponins} = \frac{W3-W1}{W2} \text{ X } 100$$

Antioxidant Vitamins Content Analysis of the Aqueous Extract of C. lanatus rinds

Determination of Vitamin E Content of C. lanatus rinds

The principle of this method relies on the reduction of Ferric ion to Ferrous ion, which produces a red color with α, α-dipyridyl dye, and the absorbance is measured at 539nm. Four test tubes were prepared and labeled as test tube 1, test tube 2, standard, and blank. In test tube 1, 0.5 ml of the sample was mixed with 0.5 ml of anhydrous ethanol, vigorously shaken for 1 minute, and then 3 ml of xylene was added and shaken vigorously again. After centrifuging to separate the extract at 1500 xg for 10 minutes, 0.25 ml of bathophenanthroline solution was added to test tube 2, followed by 1.5 ml of the upper layer extract. Then, 0.25 ml of $FeCl_3$

solution and 0.25 ml of H_3PO_4 solution were added successively and mixed. In the standard test tube, 0.5 ml of the standard solution and 0.5 ml of distilled water were added without centrifugation. The absorbance of the sample (Ax) and standard (As) was measured at 539 nm against a reagent blank prepared like the sample but using water instead of the analyzed liquid. The concentration (Cx) of vitamin E in the sample was determined using the formula:

$$Cx = \frac{\text{absorbance of sample}}{\text{absorbance of standard}} \text{ X concentration of standard (mg/dl)}$$

Determination of Vitamin A Content of C. lanatus rinds

Carotenoids are transported bound to lipoproteins. To extract them, ethanol is added to break the bonds, and the pigments were then extracted with petroleum ether. Absorbance is measured at 400 nm, and the concentration was determined using a dichromate standard. Two test tubes, labeled as test tube 1 and test tube 2, were prepared. In the test tube 1, 1 ml of the sample was mixed with 1 ml of 95% ethanol and petroleum ether, and the mixture was centrifuged. Test tube 2 received 2 ml each of vitamin A standard and petroleum ether. Both test tubes were mixed and centrifuged for 10 minutes at 2000 rpm. After centrifugation, 1 ml of the supernatant from each test tube was measured, and the absorbance read at 450 nm against a reagent blank. The concentration (Cx) of vitamin A was calculated using the formula:

$$Cx = \frac{\text{absorbance of sample}}{\text{absorbance of standard}} \text{ X concentration of standard (mg/dl)}$$

Determination of Vitamin C Content of C. lanatus rinds

The determination of Vitamin C in this method was based on its reaction with phosphotungstate to produce a green color, which is quantified spectrophotometrically at 500nm. Three test tubes were prepared and labeled as blank, test tube 1 and test tube 2. In test tube 1, 1 ml of the sample was combined with 1 ml of phosphotungstate. Test tube 2 received 1 ml each of Vitamin C standard solution and phosphotungstate. The blank test tube contained 1 ml each of distilled water and phosphotungstate. The tubes were thoroughly mixed and allowed to incubate for 30 minutes at room temperature. After incubation, they were centrifuged at 2000 rpm for 10 minutes, and the absorbance was measured at 500nm. The concentration of vitamin C was calculated using the formula:

$$Cx = \frac{\text{Absorbance of Sample}}{\text{Absorbance of Standard}} \text{ X concentration of standard (mg/dl)}$$

Statistical Analysis

The data underwent statistical analysis using the software Instat 3 version (San Diego, USA), and the results were presented as Mean ± Standard deviation. A significance level of $P < 0.05$ was considered statistically significant.

Results and Discussion

The proximate composition of *C. lanatus* rinds is presented in Table 1. The result revealed a moisture content of 6.40%, indicating good shelf stability. This value of moisture content is much higher than the value reported by Zubairu *et al*. (2018). The *C. lanatus* rind showed high contents of carbohydrate, crude fibre and crude protein but low levels of crude lipids, ash and moisture content. The ash content, which reflects the inorganic mineral content, was found to be 3.43%, similar to value reported by Sadiq *et al*. (2022), suggesting the rind's potential as a good source of mineral elements. The crude protein content (10.87%) aligns with other report by Al-Seyid and Ahmad, (2013), underscoring its nutritional relevance in enzymatic and cellular functions (LaPelusa and Kaushik, 2020). Despite the low lipid content, *C. lanatus* rind is recognised for its high crude fiber content (25.71%), making it a

valuable dietary source of fiber (Barber *et al*., 2020). The carbohydrate content obtained was comparable to previous reports (Hoque and Iqbal, 2015), suggesting its role in energy supply and other metabolic processes (Holesh *et al*., 2023). These findings elucidate the nutritional significance of *C. lanatus* rind and suggest its suitability for inclusion in diets aimed at promoting health and wellness.

Table 1: Proximate composition of *C. lanatus* rinds

Parameters	Values (%)
Moisture Content	6.40 ± 0.005
Ash Content	3.43 ± 0.008
Crude Protein	10.87 ± 0.040
Crude Lipid	1.29± 0.005
Crude Fibre	25.71 ± 0.005
Carbohydrate	50.04 ± 0.056

Values are expressed as Mean ± SD of three replicates.

Table 2: Qualitative phytochemical screening of aqueous extract of *C. lanatus* rinds

S/N	Phytochemicals	Inference
1.	Flavonoids	+
2.	Tannins	+
3.	Saponins	+
4.	Glycosides	+
5.	Alkaloids	+
6.	Steroids	+
7.	Cardiac glycosides	+
8	Saponin glycosides	+
9.	Volatile oils	+
10.	Balsams	ND
11.	Anthraquinone	ND

Key: +: present; ND: Not detected

The qualitative phytochemical result (Table 2) demonstrated the presence of Flavonoid, Tannins, Saponins, Glycosides, Alkaloids, Steroids, Cardiac glycosides, Saponin glycosides and Volatile oils.

Table 3: Quantitative phytochemical content of aqueous extract of *C. lanatus* rinds

Phytochemicals	Values (g%)
Saponins	1.69±0.07
Flavonoids	14.45±0.03
Tannins	5.64±0.42
Steroids	0.04±0.00
Alkaloids	2.30±0.01
Glycoside	0.07±0.01

Values are expressed as Mean ± SD of three replicates

The quantitative analysis of phytochemicals in *C. lanatus* rinds (Table 3) showed the presence of Saponins (1.69), Flavonoids (14.45), Tannins (5.64), Steroids (0.04), Alkaloids (2.30), and Glycosides (0.07). Flavonoids were found in the highest concentration, followed by Tannins and Alkaloids, with Steroids being the least abundant among the phytochemicals analyzed. These findings lend credence to the traditional medicinal use of *C. lanatus* rinds in treating various disorders, suggesting its potential therapeutic applications, including its noted anticancer properties (El Gizawy *et al*., 2022). These compounds are known to impart various medicinal properties to plants. For instance, Flavonoids exhibit extensive anticancer effects by participating in the cell cycle arrest, apoptosis stimulation modulation of ROS-scavenging enzyme activities, suppression of cell proliferation and autophagy (Chirumbolo *et al*., 2018). Alkaloids are valued for their analgesic and antibacterial effects (Bribi, 2018), while saponins are recognized for their effects on reducing plasma cholesterol, antioxidant activity, cytotoxic activity, cardioprotective, antiobesity and

antidiabetic potentials (Nguyen *et al*., 2020). Tannins exhibit antimicrobial, anti-inflammatory and bactericidal activities (Pizzi, 2021).

Table 4: Antioxidant vitamins content of the aqueous extract of *C. lanatus* rinds

S/N	Vitamin	Concentration (mg/dl)
1	A	67.87±0.98
2	E	143.45±1.98
3	C	37.08±5.69

Values are expressed as Mean ± SD of three replicates.

The antioxidant vitamins content of *C. lanatus* rind presented in Table 4 were: Vitamin A (67.87), Vitamin E (143.45), and Vitamin C (37.08), with Vitamin E showing the highest concentration among them and Vitamin C the least in abundance. Vitamin E functions as an antioxidant by scavenging lipid radicals and halting oxidative chain reactions (Farbstein *et al*., 2010). It also enhances immune responses in animals, including antibody production and lymphocyte proliferation (Lee and Han, 2018). Vitamin C regulates the distribution and storage of iron by maintaining the normal Ferritin to hemosiderin ratio (Bsoul and Terezhalmy, 2004), while Vitamin A is involved in red blood cell synthesis and is implicated in cancer prevention through its antioxidantive activities (Oruch and Pryme, 2012).

Conclusion

Based on the findings of this study, it is evident that *Citrullus lanatus* rind contains substantial amounts of essential nutrients, bioactive components and antioxidant vitamins. These properties, therefore, suggest its potentials as dietary supplement to combat protein-energy deficiencies and a promising material in developing new medicinal therapies.

Conflict of Interest

There are no conflicts of interest.

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