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NUTRIENT COMPOSITION OF *CITRULLUS LANATUS* (WATER MELON) SEEDS

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Abstract: **Malnutrition, more specifically to protein-energy, and micronutrient deficiencies, are major health burdens in developing countries. This study was designed to investigate the nutrient compositions of *Citrullus lanatus* seeds. Proximate, vitamins, minerals, amino acids and antinutrient compositions of *Citrullus lanatus* seeds were investigated. Proximate analysis was assessed by AOAC method minerals by atomic absorption spectrophotometry vitamins by UV- visible spectrophotometry while titrimetric methods were used for antinutrients analysis. The highest proximate composition of the seeds was crude protein (28.33±0.49%) . Predominant vitamin present was C (372.90±1.91mg/kg), most abundant mineral and amino acids present were magnesium (13.68±0.52ppm) and glutamate (7,82±0.14mg/100g) respectively. Tannin (8.94±0.09ug/g) was the highest antinutrient present. *Citrullus lanatus* seeds have lower anti-nutritional constituents and rich in vitamins, minerals and protein hence which could be useful for fortifying carbohydrate based food.**

Keywords: Citrullus lanatus, **seeds, Proximate, Malnutrition, antinutrient.**

1. INTRODUCTION

Watermelon seeds are known to be highly nutritional; they are rich sources of protein, vitamins B, minerals (such as magnesium, potassium, phosphorous, sodium, iron, zinc, manganese and copper) and fat among others as well as phytochemicals (Braide *et al*., 2012). The seeds of watermelons are known to have economic benefits especially in countries where cultivation is on the increase. The seeds are for instance used to prepare snacks, milled into flour and used for sauces. Oil from the seeds are used in cooking and incorporated into the production of cosmetics (Jensen *et al*., 2011). In spite of the various potential applications, the watermelon seeds are often discarded while the fruit is eaten. There is also limited literature on the effect of variety on the nutritional, phytochemical and antioxidant properties of the watermelon seeds.

Plants derived drugs make up a significant part of natural product based pharmaceuticals. It is very imperative that the nutrients found in many foods, fruits, seeds and vegetables are responsible for the well documented health benefits. Many plants produce secondary compounds that are useful in the management of human diseases (Manjulika *et al*., 2004). Phytomedicine refers to using a plant's seeds, berries, roots, leaves, bark or flowers for medicine purposes.

2. MATERIALS AND METHODS

Materials

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

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Apparatus

The major apparatus used were Weighing balance (Atom, China model A-110C Atomic Absorption Spectrophotometer (FS240AA agilent atomic adsorption spectroscopy, U.S.A), Gas chromatography (GC bulk scientific M910 gas chromatography U.S.A) and spectrophotometer (UV3000 apel Japan UV-VIS spectroscopy).

Experimental Plants and authentication

Water melon fruits *(Citrullus lanatus)* were purchased from Choba Market, Port Harcourt, and the plant seeds were identified and authenticated in the Department of Plant Science and Biotechnology (PSB), University of Port Harcourt, by Dr. E. Chimeze with herbarium voucher number UPH/P/183 and the specimen deposited in the herbarium.

Estimation of proximate composition

Dried and ground seeds of the plant were used for proximate analysis.

Moisture composition estimation

The technique described by AOAC (2006) was adopted.

Principle

Exposure of tissues to high temperature between 100-105^{0}C for long period, will cause it to virtually dehydrate and as a result reduce weight. The reduction in weight is constant until the constant weight is reached that dehydration can no longer occur. This constant weight is the dry matter content while the weight lost is moisture content.

Procedure

A clean crucible was dried to a contant weight in an air oven at 105^{0}C, cooled in a dessicator, weigh and labeled (W_1). Then 2 g of the ground sample was accurately weighed into the previously labeled crucible and reweighed (W_2). The crucible containing the sample was dried in an oven to a constant weight (W_3).

Calculation

$$\% \text{ Moisture content} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Determination of ash content

The AOAC (1999) method was applied to estimate ash content.

Principle

The organic portions of samples are changed to gaseous compounds (e.g. oxides, etc), when heated to elevated temperature of about 560^{0}C and 600^{0}C, left behind a grayish-white of the inorganic part. The ash is estimated by measuring the inorganic residue.

Procedure

The porcelain crucible was placed in an oven for it to dry at 100^{0}C for 10 minutes, cooled in a dessicator and measured (W_1). Then 2 g of the sample that was smoothly ground was accurately weighed into initially weighed porcelain crucible and reweighed (W_2). It was first ignited and then moved to a furnace of 560^{0}C. The sample was left in the furnace for eight hours to ensure proper ashing. The crucible containing the ash was then removed cooled in the dessicator and weighed (W_3).

Calculation

$$\% \text{ Ash content} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

Determination of crude lipid content

The lipid content was determined by the method of AOAC (2006).

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Principle

This method measures lipid which is extracted by solvent such as petroleum ether. The extraction depends on the sparing solubility of lipids in water and their considerable solubility in non polar organic solvents (i.e. solvents of hydrophobic nature). The solvent is evaporated off to get the lipid. The measured lipid consists of all the soluble materials present in the sample.

Procedure

A clean dried 500 ml round bottom flask, containing few anti bumping granules was weighed (W_1) and 300 ml of petroleum ether (40-60^{0}C) for the extraction was poured into the flask made to suit the soxhlet extraction unit. The extraction thimble containing 2g of sample inside the extraction thimble was placed in the soxhlet extraction unit. The round bottom flask and a condenser were connected to soxhlet extractor and cold water circulation was turned on. The heating mantle was switched on and the rate of heating was regulated till the solvent was refluxed at a steady rate. This process was done for 6 hours until the solvent was recovered, then the oil was dried in the oven at 70^{0}C for 1 hour. The round bottom flask and oil were cooled and then weighed (W_2).

Calculation

$$\% \text{ Lipid content} = \frac{W_2 - W_1}{\text{Wt of sample}} \times 100$$

Determination of crude fibre content

The AOAC (2006) technique was used.

Principle

Boiled sulphuric acid (H_2SO_4) was used to clean a fat- free sample and later with boiling sodium hydroxide (NaOH). After removing the ash from the residue, fibre was got.

Procedure

Two grams of finely ground sample was weighed out into round bottom flask, then 100 ml of 0.25 M sulphuric acid solution was added and the mixture boiled under reflux for 30 min. The hot solution was quickly filtered under suction. The insoluble matter was washed many times with hot water until it was free from acid. It was quantitatively transferred into the flask and 100 ml of hot 0.31 M sodium hydroxide solution was added and the mixture boiled again under reflux for 30 minutes and quickly filtered under suction. The residue was washed with hot water until it was base free. It was dried to a constant weight in the oven at 100^{0}C, cooled in a dessicator and weighed (C_1). The weighed sample (C_1) was then incinerated in a furnace at 550^{0}C for two hours, cooled in a dessicator and reweighed (C_2).

Calculation

$$\% \text{ Crude fibre content} = \frac{C_1 - C_2}{\text{Wt of original sample}} \times 100$$

Where C_1- C_2 = the loss in weight on incineration

Estimation of crude protein content

The technique of Kjeldahl as described by Onyeike and Ayalogu (2003) was applied to estimate crude protein.

Principle

The procedure involves digesting the material with concentrated tetraoxosulphate (vi) acid (H_2SO_4) using copper sulphate as a catalyst to convert organic nitrogen to ammonium ions. Alkali is added and the liberated ammonia distilled into an excess of boric acid solution. Then hydrochloric acid was used to titrate the distillate to known the ammonia absorbed in the boric acid.

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Procedure- Protein digestion

Exactly 1.5 g of the ground defatted sample in an ashless filter paper was dropped into 300 ml Kjeldahll flask, 25 ml of concentrated H_2SO_4 and 3 g of digestion mixed catalyst (weighed separately into an ashless filter) were also dropped into the Kjeldahll flask which was then transferred to the Kjeldahl digestion apparatus. The ground sample was fully absorbed until a clear green colour was seen. The absorbed sample was left to cool and was diluted with distilled water to 100 ml.

Distillation of Digest

To 500 ml Kjeldahl flask containing anti-bumping chips and 40% NaOH was added 200 ml of diluted digest slowly by the side of the flask. A conical flask of 250 ml containing a mixture of 50 ml 2% boric acid and four drops of diluted indicator was used to trap the ammonia being liberated. The conical flask and the Kjeldahl flask were then put on Kjeldahl distillation apparatus; with the tubes inserted into the conical flask and the Kjeldahl bottle. The flask was heated to distill out the ammonia (NH_3) evolved and the distillate was collected into boric acid solution. When the colour of the boric acid in the receiving flask changed from purple to pale green, distillation was stoped. The distillation unit was dismantled and rinsed with distilled water. Exactly 0.1 M HCl was used to titrate the distillate (boric-acid ammonia solution), until pink colour was seen.

Calculation

$$\% N_2 = \frac{14 \times M \times V_1 \times T_{V \times 100}}{\text{Wt of sample (mg)} \times V_2} \times 100$$

% Crude protein = % nitrogen (N_2) × 6.25

Where M = actual molarity of acid

T_v = titre volume of HCl used

V_1 = total volume of diluted digest

V_2 = aliquot volume distilled

3. DETERMINATION OF ANTINUTRIENT PHYTOCHEMICAL COMPOSITION

Determination of oxalate

The method of Bello *et al*. (2008) was used in the estimation of oxalate content.

Determination by titration method

This determination involves three major steps which are digestion, oxalate precipitation and permanganate titration.

(i) Digestion; sample (0.2g) was suspended in 250ml volumetric flask

(ii) Ten milliliter rof 6MHCl was added and the suspension digestion at 1000^0c for 1hr

(iii) The solution was cooled and then mixed up to 250ml mark before titration.

Oxalate precipitation

Duplicate portions of the fitrate were measured in to beakers and four drops of four drops of methyl red indicator added. Then, NH_4OH solution was added (drop wise) until the test solution changed from pink to faint yellow colour (p^H 4.0-4.5). Each portion was then heated to 90^0C cooled and filtered to remove precipitate containing ferrous iron. The filtrate was again heated to 90^0 C and 10ml of 5% $CaCl_2$ solution was added while being stirred constantly. The solution was then heated and left overnight at 25^0C, it was being centrifuge at 2500rpm for 5minutes. The supernatant was decanted and the precipitate was completely dissolved in 10ml of 20% H_2SO_4 solution.

Permanganate titration

At this point, the total filtrate resulting from digestion of 2g of sample was made up to 300ml. Aliquots of 125mlof the filtrate was heated until near boiling and then titrated against 0.05m standardized $KMnO_4$ solution to a faint pink colour which persisted for 30seconds. The calcium oxalate content was calculated using the formular;

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$T \times \frac{(Vme\ (Df)}{(ME) \times Mf} \times$ (mg (100)

Where T is titration of $KMnO_4$ (ml)

Vme is the volume mass equivalent

Df is the Dilation factor $= \frac{Vt}{A}$

Where Vt is the total volume of filtrate (300ml)

And A is the aliquot used i.e 250ml

ME is the molar equivalent of $KMnO_4$ in oxalate and Mf is the mass of sample used.

Determination of tannin content

The technique of Schofield *et al*., (2001) was used to analyze the total phenolic compounds. The sample was diluted with distilled water to a known level so as to get reading between the standard curve ranges of 0.0 to 600 µg of tannin acid/ml. Exactly 250 µl of tannic acid solution was diluted with 1 ml of distilled water in a test tube thereafter 250 µl of Folic-Ciocalteu reagent was added. The tube content was mixed throughly and was allowed to stand for 5 mins at room temperature so as to enable complete reaction with the Folin-Ciocalteuu reagent. It was followed by the addition of 2.5 ml of 7% sodium carbonate aqueous solution and distilled water was used to make the final volume to 6.0 ml. The absorbance of the resultant blue colour solution was measured spectrophotometrically at a wavelength of 760 nm after heating and incubating the sample for 90 min.

The determination of tannins content in the test extracts was performed using Makkar *et al*., (1993) method. Polyvinyl poly-pyrrolidone (PVPP) of 100 mg was weighed, and then 1.0 ml of distilled water followed by 1.0 ml of the tannin containing extract were added. This mixture was stirred for 60 minutes, afterwards centrifuged for 10 min and finally the supernatant was collected.

The supernatant had only simple phenolic compounds other than tannins. The phenolic content of the supernatant was then evaluated by the Folin-Ciocalteau reaction and this was accepted as the non-tannin phenols (NTP) (Makkar, 2003). The total tannins content was calculated as the diffrence between total phenol and non-tannin phenols. The content of non-tannin phenols was expressed on a dry plant basis (y%), and the percentage of tannins was calculated as tannin acid equivalent, estimated as grams per 100 grams dried plant as follows:

Tannin percentage = (x%) – (y%)

Where x% is the percentage of the total phenolic compounds (g/ 100g dried plant), y% is the non-tannin phenols content (g per 100 grams dried plant).

Determination of phytic acid content

The technique of Lucas and Markakas (1975) was used to estimate phytic acid content in which 2.0 g of the sample was measured in a 250 ml conical flask. The sample was soaked in 100 ml of 2% concentrated hydrochloric acid (HCl) for 3 hour and then filtered with a Whatman No. 1 filter paper. The filtrate was taken (50 ml) and 10 ml of distilled water was added in each case to produce proper acidity. Thereafter, 10 ml of 0.3% ammonium thiocyanate solution was added in the solution as indicated and titrated with standard Iron II chloride solution comprising 0.00195 g iron/ml, yellow colour was seen at the end which persisted for 5 min. The percentage phytic acid % was calculated using:

% phytic acid = y × 1.19 × 100

Where, y = titre value × 0.00195 g

Determination of mineral composition

Atomic Absorption Spetrophotometer (AAS) was used to estimate the mineral content of the sample.

Principle

When samples are aspirated into a flame through the air stream as a fine mist, this passes into the burner through a mixing chamber, the air meets the fuel gas (acetylene) supplied to the burner at a given pressure and the mixture is burnt. The radiations from the resulting flame through a lane, and finally through an optical filter which permits only the radiation characteristics of the element under investigation to pass through the photocell. The atoms held are irradiative with the light produced by the cathode lamp. These atoms held absorb some of the incident radiation, and the amount absorbed is proportional to the concentration of the sample in mg/l, then the output from the photocell is measured on a suitable digital read out system and is finally printed out via a printer.

Procedure

The sample was air dried and crushed to a very fine power in a Creston high speed grinder, and 1 g of the pulverized sample was weighed into a clean crucible. It was ashed at 550^0C for 2 hours and transferred into a 250 ml beaker. To it, 15 ml of concentrated hydrochloric acid (HCl) and 5 ml of conc. Trioxonitrate (v) acid (H_2NO_3) were added. The beaker was moved to a hot plate and heated to dryness at 100^0C. To it, 10 ml of distilled water was added and filtered into 100 ml volumetric flask and was annalysed using the Atomic Absorption Spectrophotometer (AAS).

Determination of vitamin composition

The vitamin composition of the sample was got using UV- visible spectrophotometer.

Principle

When a beam of monochromatic light goes through a solution of an absorbing substance, the rate of reduction of radiation intensity with thickness of the absorbing solution is proportional to the incident radiation as well as the solution concentration of the solution.

Procedure

To 10 ml of methanol was added 0.5 g of the sample. It was filtered and poured into a cuvette for analysis using uv-visible speed for various vitamins based on their standard calibration curves.

Determination of amino acid

Procedure

The modified method of AOAC (2006) was used to determine amino acid in the sample.

The dried and pulverized sample was dried further to ensure constant weight for a period of time in the laboratory. Exactly 10.0g of the sample was weighed into 250ml conical flask. The sample was deffated by extracting the fat content of the sample using 30ml of petroleum spirit thrice. The sample was hydrolyzed three times for complete hydrolysis. The content of amino acids in the sample was recovered by extracting with 30ml of the dichloromethane thrice before concentrating to 1.0ml. The concentrated extract was derivatised for volatility that is suitable for gas chromatogragh analysis.

Statistical analysis

All data were analyzed using SPSS for window package version 24 and are presented as means $\pm$ standard error of triplicate determination.

4. RESULTS AND DISCUSSION

Results

Proximate composition of *Citrullus lanatus* seeds

Table 1 shows the proximate composition of *Citrullus lanatus* seeds sample. The protein content was highest with the value of 28.32 ± 0.49% followed by moisture content (24.18 ± 0.19%), fat content (19.04 ± 0.13%), fibre content (13.99 ± 0.05%), carbohydrate content (10.07±0.45%) and ash content (4.45 ± 0.02%) which has the least value.

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Antinutrient Phytochemicals composition of *Citrullus lanatus* (water melon) seeds

Tables 2a and 2b showed the phytochemical composition of *Citrullus lanatus* seeds sample. Qualitative and quantitative analysis showed the presence of tannin, saponin, oxalate and phytate with tannin having the highest (8.95 ±0.09), oxalate (6.75 ± 0.06) and phytate (1.45 ± 0.09) which has the least concentration.

Table 1: Proximate composition of *Citrullus lanatus* (water melon) seeds sample

PROXIMATE	CONCENTRATION (%)
Ash content	4.45 ± 0.02
Moisture content	24.18 ± 0.19
Protein	28.32 ± 0.49
Fibre	14.00 ± 0.05
Fat	19.03 ± 0.13
Carbohydrate	10.07 ± 0.45

Values are represent in Mean ± SEM of triplicate sample

Table 2a: Qualitative anti nutritrient phytochemicals composition of *Citrullus lanatus* (water melon) seeds sample

PHYTOCHEMICALS	OBSERVATION
Tannin	+
Oxalate	+
Phytate	+

Note: (+) represent very low

Table 2b: Quantitative anti nutrients phytochemical composition of *Citrullus lanatus* (water melon) seeds sample

PHYTOCHEMICALS	CONCENTRATION (ug/g)
Tannin	8.95 ± 0.09
Oxalate	6.75 ± 0.06
Phytates	1.45 ± 0.09

Values are represent in Mean ± SEM of triplicate sample

Vitamins composition of *Citrullus lanatus* (water melon) seeds sample

Table 3 shows vitamin composition of the *Citrullus lanatus* seeds. The seed showed the presence of both water and fat soluble vitamins. The water soluble vitamins present were vitamins C, B_6, B_2, B_1 and B_3 with vitamin C having the highest value (372 .90 ± 1.91mg/kg) and vitamin B_3 had the lowest value (0.81±0.00mg/kg). The fat soluble vitamins found were vitamins A, E, and D with vitamins A (50.61 ± 0.60mg/kg) and D (13.98 ± 0.24mg/kg) having highest and lowest value respectively.

Minerals composition of *Citrullus lanatus* (water melon) seeds sample

Table 4 showed the minerals composition of *Citrullus lanatus* seeds. The macrominerals present were magnesium, calcium, sodium and potassium with magnesium having the highest value (13.68 ± 0.52ppm) and potassium (5.08 ± 0.02ppm) having the least value while the microminerals were zinc, iron, cobalt, selinium, cupper and phosphorus with zinc having the highest value (0.57±0.02ppm) and phosphorus was having the lowest value (0.03 ± 0.00ppm).

Amino acids composition of *Citrullus lanatus* (water melon) seeds sample

Table 5 showed the amino acids composition of *Citrullus lanatus* seeds. The essential amino acids present were arginine, histidine, lsoleucine, leucine, lysine, methionine, phenyalanine, threonine, tryptophan and valine with leucine having the highest value (7.14 ± 0.04mg/100g) while tryptophan had the lowest value (1.19 ± 0.02mg/100g). Non essential amino acids present were alanine, aspartate, cysteine, glutamate, glutamine, glycine, proline, serine, and tyrosine with glutamate having the highest value (7.82 ± 0.14mg/100g) while cysteine had the lowest value (1.08 ±0.00).

Table 3: Vitamins composition of *Citrullus lanatus* (water melon) seeds sample

VITAMINS	CONCENTRATION (mg/kg)
Vit B1	2.14 ± 0.05
Vit B2	2.54 ± 0.08
Vit B12	1.07 ± 0.00
Vit B3	0.81 ± 0.00
Vit B6	125.50 ± 0.29
Vit C	372.90 ± 1.91
Vit E	8.86 ± 0.10
Vit A	50.61 ± 0.60
Vit D	13.98 ± 0.24

Values are represent in Mean ± SEM of triplicate sample

Table 4: Minerals composition of *Citrullus lanatus* (water melon) seeds sample

MINERALS	CONCENTRATION (ppm)
Mg	13.68 ± 0.520
Na	5.39 ± 0.01
Zn	0.57 ± 0.02
Fe	0.54 ± 0.01
Co	0.44 ± 0.01
K	5.08 ± 0.02
Ca	5.40 ± 0.09
Se	0.14 ± 0.00
Cu	0.09 ± 0.00
P	0.03 ± 0.00

Values are represent in Mean ± SEM of triplicate sample

Table 5: Amino acids composition of *Citrullus lanatus* (water melon) seeds sample

AMINO ACIDS	CONCENTRATION (mg/100g)
Glycine	2.71 ± 0.021
Alanine	2.49 ± 0.00
Serine	3.89 ± 0.05
Proline	4.29 ± 0.00
Valine	5.71 ± 0.03
Threonine	3.72 ± 0.01
Isoleucine	4.07 ± 0.03
Leucine	7.15 ± 0.04
Aspartate	4.52 ± 0.03
Lysine	1.36 ± 0.01
Methionine	1.29 ± 0.01
Glutamate	7.82 ± 0.14
Phenylalanine	3.32 ± 0.08
Histidine	2.31 ± 0.00
Arginine	4.76 ± 0.06
Tyrosine	3.34 ± 0.02
Tryptophane	1.19 ± 0.02
Cysteine	1.08 ± 0.00

Values are represent in Mean ± SEM of triplicate sample

5. DISCUSSION

Table 1 shows the proximate compositions of *Citrullus lanatus* seeds as crude protein, moisture, crude fibre, carbohydrate and ash contents in descending order. This result varies in percentages when compared with the proximate compositions of watermelon seed reported by Oyeleke *et al*. (2012); Ugwuanyi (2012); Kiin- Kabari and Akusu (2014); Omoboyowa

et al. (2015); Otutu *et al*. (2015); Jacob *et al* (2015); Betty Tabiri *et al*.(2016) Addo et al. (2018)and Milala *et al*. (2018) probably due to the different species of the plant used. Proximate analysis showed that *Citrullus lanatus* seeds are high in calories due to high content of protein, fat and carbohydrate which make them a source of energy which help in the utilization of other nutrients that are necessary to life. Apart from the nutritional significance of protein as a source of amino acids, it also plays a part in the organoleptic properties of foods (Essien et al., 2009). Dietary fat adds to the palatability of food through absorption and retaining of flavor(Luvonga, 2012) The high fibre content in vegetables serves as a serum cholesterol reducing agent and thus helps to prevent the risk of coronary heart diseases and hypertension(Uyoh et al. 2013)

Qualitative and quantitative analyses of antinutrient compositions showed the presence of tannin, oxalate and phytate with concentrations in descending order (Tables 2a and 2b). Several studies on antinutrient compositions of *Citrullus lanatus* seeds by Johnson *et al.* (2012); Jacob *et al* (2015); Omoboyowa *et al*. (2015); Egbuonu (2015b); Addo et al. (2018); Amadi *et al* (2018); Olumuyiwa et al.(2020); and are inconsistent in concentration with the present study due to different varieties of *Citrullus lanatus* plant used in the studies. However what is consistent was that the levels of anti-nutritional compounds present in *Citrullus lanatus* seed in all the studies were below FAO/ WHO allowable limits. Tannins have been reported to decrease protein digestibility and palatability (Jakobek, 2015). Phytate act as mineral and protein chelating agent and have been found to negatively affect protein digestibility, solubility and functionality (Megat-Rusydi and Azrina, 2012). At the moderate level, phytate has a high affinity to bind zinc and lower the ratio of plasma zinc to copper and therefore lowers the risks of cardiovascular diseases (Igile et al. 2013). Oxalate in the body at a small proportion is useful in reducing the risks of cancer. High content of oxalate in the body decreases the absorption of Ca and increase the formation of kidney stone(Official Methods of Analysis. 2019).

Table 3 shows vitamin composition of the *Citrullus lanatus* seeds. The seed showed the presence of both water and fat soluble vitamins. The water soluble vitamins present were vitamins C, B_6, B_2, B_1 and B_3 with vitamin C as the highest value. The fat soluble vitamins found were vitamins A, E, and D with vitamins A having the highest value. Similarly, Omoboyowa *et al* (2015) and Egbuonu (2015a) reported that vitamin contents of watermelon seed included Vitamins C, A, B_2, B_1 and B_3, however vitamin C content of watermelon seed in the present study was higher than that in both studies. Vitamin C helps in building immunity against diseases, purification of blood and teeth and bones formation. Vitamin A promotes resistance to diseases, delay in ageing and improve the health of eyes, nails and hairs(Salami S.O., & Afolayan,2020). Vitamin D helps to improves insulin sensitivity by stimulating insulin receptor expression (Kos *et al*., 2012).

Vitamin E has been reported to be a good antioxidant necessary for the formation of red blood cells and also useful for recovery and maintenance of muscle and other tissues (Eric et al.2014).

Table 4 showed the minerals composition of *Citrullus lanatus* seeds. The macrominerals present were magnesium, calcium, sodium, phosphorus and potassium with magnesium having the highest value while microminerals were zinc, iron, cobalt, selenium, and cupper with zinc having the highest value. Similarly, magnesium, calcium, sodium, potassium, zinc, phosphorus, and iron were present in watermelon seed as reported by Umar and Shuaibu (2013), Egbuonu (2015a), Samuel (2016) and Morais *et al*. (2017) However, the mineral contents of all the minerals in the above cited studies were higher than the present study. Magnesium is important in the transmission of nerve impulse and muscle contraction. Zinc is vital for good brain development, bone formation and healing of wounds(NHMRC., 2000) and very important in nucleic acid synthesis. Fe is required for the production of hemoglobin, the transport of O2, and to increase the body's immunity (Glew et al. 2005).

Table 5 showed the amino acids composition of *Citrullus lanatus* seeds. The essential amino acids present were arginine, histidine, lsoleucine, leucine, lysine, methionine, phenyalanine, threonine, tryptophan and valine with leucine having the highest value while non essential amino acids present were alanine, aspartate, cysteine, glutamate, glutamine, glycine, proline, serine, and tyrosine with glutamate having the highest value. Ali (2006), Taiwo *et al*. (2008) and Umar and Shuaibu (2013) reported the presence of isoleucine, histidine, leucine, lysine, phenylalaline, methionine, threonine, valine, aspartic acid, glutamic acid, serine, arginine and alkaline in *Citrullus lanatus* seeds consistent with that found in this study. The seeds contain a wide range of amino acids that are used for building of proteins and act as intermediate in protein metabolism. In addition, they provide materials for cells to stabilize their organization (Berg *et al.*, 2012).

6. CONCLUSION

Citrullus lanatus seeds have lower anti-nutritional constituents and rich in vitamins, minerals and protein hence which could be useful for fortifying carbohydrate based food.

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