Nutrient composition of watermelon (*Citrullis lanatus* (Thunb.) Matsum.&Nakai) and *egusi* melon (*Citrullus colocynthis* (L.) Schrad.) seeds

Olumuyiwa S. FALADE
Israel O. OTEMUYIWA (✉)
Abolanle S. ADEKUNLE
Steve A. ADEWUSI
Olatunbosun OLUWASEFUNMI

Summary

This study investigated the nutrient composition of the seeds of two cultivars of *Citrullis lanatus* ('Rhotmas' and 'Sugar Baby') and compared it with *Citrullus colocynthis*. The moisture content, ash, crude fiber, ether extract, crude protein and true protein ranged from 5.43 to 6.82, 2.78 to 3.72, 1.66 to 3.94, 55.7 to 58.7, 19.16 to 25.18 and 10.8 to 13%, respectively. The starch content, total sugar and reducing sugar varied between 143.7 and 172.7, 53.7 and 96.5, 5.6 and 9.5 mg/g, respectively. Iron, copper, zinc, calcium and magnesium ranged from 191 to 211, 20.12 to 35.03, 68.97 to 92.57, 98.79 to 233, and 79.75 to 123.9 mg/kg, respectively. Heavy metals (lead and cadmium) and antinutrients (phytate, oxalate and cyanide) were below deleterious levels. Arginine, glutamic acid and aspartic acids were the most abundant amino acids, whereas lysine was the limiting amino acid. It is concluded that watermelon seeds were better in nutritional value compared to *egusi* melon seeds and therefore could be regarded as a potential sources of food if exploited.

Key words

amino acid, anti-nutrient, mineral, nutritive value, vitamins

Department of Chemistry, Obafemi Awolowo University, Ile-Ife, Nigeria

✉ Corresponding author: otemuyisegun@oauife.edu.ng

Received: October 18, 2018 | Accepted: October 1, 2019

Introduction

In developing countries like Nigeria, one of the possible ways of overcoming food security challenges vis-à-vis growing population is the exploitation of the underutilized plants and animal foods (Achu et al., 2005). Serious protein deficiencies and high cost of animal protein sources have stimulated research into developing new sources of protein from unexploited, underutilized seeds, wastes and by products (El Safy et al., 2012) One of such underutilized seed is watermelon (*C. lanatus*) seed. The principal use of watermelon is consumption of its crisp, succulent, refreshing pulp as a dessert or snack. In the arid region of Africa, watermelon fruit provides a source of liquid as a 'living canteen'. The rind may be used for a delicious sweet pickle. Seeds are dried and used as a snack food both in China and Israel. Unwholesome fruits are used as livestock feed while immature fruits may be prepared and used as summer squash (Wani et al., 2011).

In Nigeria, while the pulp of watermelon is eaten, the seeds are usually thrown away as waste. This 'waste material' could pose ecological problems related to proliferation of insects and rodent. While seeds of *C. lanatus* are discarded, that of *C. colocynthis* (*egusi* melon) is widely cultivated for its seeds, which are utilized both as condiment and thickener in Nigerian local soup. The rind of *C. colocynthis* (*egusi* melon) fruit is white in colour when fresh, firm, bitter and not edible (Anuebunwa, 2000; Gusmini et al., 2004).

There are few studies on the nutritive value and physicochemical properties of *egusi* melon seed oils, but research report is scarce on the nutritional value of watermelon seeds. Falade and Obuseh (2014) reported the oil extracted from watermelon seeds compared favorably with conventional oil and even better than egusi melon seed oil. The objectives of this study were to investigate the chemical compositions, nutritional and anti-nutritional factors of watermelon (*C. lanatus*) seeds, and compare the results with that of *C. colocynthis* (egusi melon) with the aim of utilizing the seeds as human and animal foods.

Materials and methods

Sample and sample preparation

Watermelon cultivars 'Rothmas' and 'Sugar Baby' and *egusi* melon (*C. colocynthis*) fruits were collected from Agricultural Research Farm of Obafemi Awolowo University, Ile-Ife, Nigeria. Seeds were manually separated from the fruit pulp, cleaned, washed with distilled water, air dried and shelled manually to remove seed coats. The resulting kernels were dried at 50°C in an air oven to a constant weight. The dried kernels were milled with waring blender (National model MX-795N, Matsushita, Malaysia) into fine powder and sieved with a sieve with mesh number 60. The samples were placed in plastic container and stored in refrigerator.

Proximate Composition

The methods of AOAC (2000) were used to determine proximate composition: moisture (method 925.098); crude fiber (method 973.18); ashes (method 923.03); ether extract (method 920.39), and crude protein (method 960.52). The carbohydrate content was estimated by difference. Neutral detergent fiber (NDF) was determined using the method of Van Soest et al. (1991). Minerals were determined using atomic absorption spectrophotometer after wet digestion process. All determinations were carried in triplicate.

Determination of True Protein

True protein was determined by the method of Adewusi et al. (2003). The protein content of the sample was first solubilised at pH 10, filtered and the protein content of the filtrate precipitated at pH 4.0. The nitrogen content of the precipitate was then determined by the Micro-Kjeldahl method (AOAC, 2000), and the nitrogen value was converted to true protein by multiplying it by 6.25.

Determination of *in-vitro* protein digestibility

The *in-vitro* protein digestibility was determined by multienzyme method. The sample (250 mg) was suspended in 15 ml of 0.1M HCl solution containing 1.5 mg pepsin. The mixture was shaken gently for three hours, the suspension was neutralised with 0.5M NaOH and then treated with 4.0 mg pancreatin (prepared in 7.5 ml of 0.2M sodium phosphate buffer (pH 8.0) containing 0.005M sodium azide). The suspension was shaken again for 24 hours at room temperature. The suspension was filtered, the residue washed with distilled water, air dried and used for protein determination (AOAC, 2000). Protein digestibility was obtained by using the equation below:

$$\%\ \textit{in-vitro}\ \text{digestibility} = ((I - F) / I) \times 1000$$

where:

I is protein content of sample before digestion and
F is protein content of sample after digestion.

Total and reducing Sugar content

The soluble sugar in the sample (2.0 g) was extracted with 85% (v/v) ethanol by refluxing for two hours using Soxhlet extractor as described by Bainbridge et al., (1996). The total and reducing sugar were determined from the ethanolic extract by the ferricyanide method (AOAC, 1984). Absorbance was taken at 380 nm and glucose was used as standard, with a linear range of 0 - 100 mg /10 ml reaction mixture ($R^2 = 0.973$)

Starch content

The starch content of the samples was determined on the residue of the ethanolic extract. The residue (200 mg) was refluxed with 0.7M HCl for 2.5 hours, the acid hydrolysate was neutralized with 0.5M NaOH, made up to volume in a 500 ml standard flask with distilled water and then filtered through a Whatman no. 541 filter paper. The starch content was then determined as reducing sugar using the ferricyanide method AOAC (1984), as described above, and the reducing sugar value multiplied with 0.9 to convert it to starch.

Water soluble vitamins

The water soluble vitamins were determined by the method of Khor and Tee (1996) as modified by Otemuyiwa and Adewusi (2013). A high performance liquid chromatography (HPLC) that was equipped with UV detector (Agilent Technologies Model 1200, Germany) was used.

Amino Acid Profile

The amino acid profile was determined by High Performance Liquid Chromatography method of Batholomeo and Maisano (2006). The sample (10-20 mg) was hydrolyzed by adding 1 ml of 6M HCl and the amino acids in the hydrolysate were derivatized with phenylisothiocyanate (PITC) to produce phenylthiocarbamyl (PTC) amino acids. The derivatized sample was dissolved in 0.02 M Na_2HPO_4 (pH 4), filtered and the amino acid profile of the filtrate determined using HPLC (Waters 2X Model 510, pump Model 440, Absorbance detector 717 plus Auto-sampler, Waters Corporation, USA). The eluting solvent system used was 0.14 M sodium acetate pH 5.7 and acetonitrile (40:60 ratio). Identification and quantification of the amino acids in the samples were carried out by comparing their retention times and areas with that of the standard amino acids that were ran along with the samples.

Phytochemical Screening

The methods of Odebiyi and Sofowora (1978) were used for the qualitative screening of samples for the presence of alkaloid and saponins. The presence of alkaloids was tested by Dragendorff's, Meyers, Wagners and 10% (w/v) tannic reagents. These reagents were added separately to 1.0 ml of methanolic extract of the sample. Turbidity or precipitate is taken as evidence of the presence of alkaloids. Froth test was carried out for the presence of saponins.

Determination of anti-nutritional compounds

Phytate was determined by the anion exchange method as described by Harland and Oberleas (1986). Tannin was determined by the modified vanillin-hydrochloric acid (MV-HCl) method of Price et al. (1978) using catechin as the standard with the linear range of 0 - 1.0 mg·mL^{-1} (R^2 = 0.923). Cyanide content was determined colorimetrically according to the modified method of Haque and Brandury (2002), while oxalate content was determined by gravimetric/redox titration method as described by Falade et al. (2005).

Statistical analysis

Results were expressed as mean and standard deviation of triplicate analysis. Data were subjected to one-way analysis of variance to determine the levels of significant difference by performing a multiple comparison *post hoc* test (Tukey's HSD test). The data were considered significant at $P \leq 0.05$. GraphPad Instat software version 3.06 for Windows was used for the analysis.

Results and discussion

The results of proximate composition of *C. lanatus* (watermelon) and *C. colocynthis* (*egusi* melon) seeds are presented in Table 1. The percentage moisture content ranged from 5.43 to 6.82%, and the values recorded for 'Rothmas' and 'Sugar Baby' cultivars were lower than for *C. colocynthis*.

Table 1. Chemical composition of *Citrullis lanatus* (watermelon) and *Citrullus colocynthis* (melon) seeds (dry weight basis)

Samples	*Citrullis lanatus*		*C. colocynthis*
	'Rothmas'	'Sugar Baby'	
Moisture (%)	5.98 ± 0.11^{b}	5.43 ± 0.11^{c}	6.82 ± 0.26^{a}
Ash (%)	3.51 ± 0.18^{ab}	3.72 ± 0.06^{a}	2.98 ± 0.09^{b}
Crude fiber (%)	2.25 ± 0.05^{b}	1.66 ± 0.004^{c}	3.94 ± 0.06^{a}
Neutral detergent fiber (%)	11.63 ± 0.73^{a}	11.98 ± 0.11^{a}	10.04 ± 0.31^{b}
Ether extract (%)	57.51 ± 2.17^{ab}	55.72 ± 1.07^{b}	58.77 ± 1.71^{a}
Crude protein (%)	25.18 ± 0.10^{a}	22.97 ± 0.23^{b}	19.16 ± 1.27^{c}
True Protein (%)	13.0 ± 0.9^{a}	11.5 ± 0.5^{a}	10.8 ± 0.5^{b}
In-vitro protein digestibility (%)	64^{b}	62^{c}	69^{a}
Carbohydrate (%)	5.57 ± 0.1^{c}	10.5 ± 0.03^{a}	8.33 ± 0.05^{b}
Reducing sugar (mg/g)	5.60 ± 0.82^{c}	9.54 ± 0.81^{a}	7.36 ± 0.26^{b}
Total sugar (mg/g)	53.76 ± 3.23^{c}	69.35 ± 4.78^{b}	96.53 ± 2.41^{a}
Starch (mg/g)	163.9 ± 9.93^{ab}	143.7 ± 4.75^{b}	172.7 ± 14.3^{a}

Mean ± standard deviation of triplicate analysis

Values with the same superscripts across the rows are not significantly different according to Tukey's HSD test ($P \leq 0.05$)

The moisture content of the samples was similar when compared with 5.5% reported for watermelon (Essien et al., 2009). This shows that these seeds will have high shelf life. The ash content of *C. colocynthis* was significantly lower ($P < 0.05$) than in 'Sugar Baby' watermelon. This implies that *C. lanatus* is richer in mineral than *C. colocynthis*, since ash is a measure of mineral content.

The neutral detergent fiber (NDF) recorded for the samples (Table 1) was higher than crude fiber. NDF is a measure of soluble fiber. This class of fiber has been reported to form a gel that slows down gastric emptying and the transit time of food through the digestive system. Fiber had been reported to extend food satiation period, delays the absorption of sugar and hence reduces the blood glucose level (Pereira et al., 2005). The consumption of these watermelon seeds could help in the management of diabetes. The NDF values recorded in this work were lower than the range of 29.2 and 32.7% reported for some *Acacia* species seeds, but higher than the values reported for cowpea and maize (Falade et al., 2005; Bressani et al., 1989). It has been reported that a diet low in fiber is undesirable because it can lead to health disorders like constipation, irritable bowel syndrome, overweight and obesity, coronary heart diseases, diabetes and colon cancer (Wu et al., 2003).

Ether extract was significantly different only between *egusi* melon and 'Sugar Baby' watermelon samples and it is similar with 53.9% reported for groundnut (Falade et al., 2008), but higher than a range of 47.9 - 51.1% and 40% reported for pumpkin and watermelon seeds, respectively (Fagbemi and Oshodi, 1991; Essien et al, 2009). The high content of lipid recorded for watermelon could be an advantage because of high demand for vegetable oil for industrial purposes.

Crude protein concentration recorded for *C. lanatus* ('Rothmas' and 'Sugar Baby') was higher than for *C. colocynthis*. This shows that watermelon seeds could be of higher nutritional value compared with *egusi* melon seeds, hence could replace or complement *egusi* melon seeds as a source of protein. The protein contents of the samples reported in this work is similar with 24.5% reported for watermelon (Essien et al., 2009). Higher protein value 30.1 - 33.8% was reported earlier for watermelon (El-Safy et al., 2012); the difference compared to our result could be due to either varietal difference or climatic conditions where the samples were planted. It has been reported that soil and climatic conditions affect the chemical composition of plant foods (Gusmini et al., 2004).

The true protein (10.8 to 13%), which measures the extractable protein, was found to be lower than crude protein. This is expected because true protein determination excluded non protein nitrogen compounds such as urea which are included in crude protein. Results of percentage *in-vitro* protein digestibility (Table 1) showed that the protein digestibility of *egusi* melon seeds was marginally higher than that of watermelon seeds. There was a strong negative correlation ($r = -0.98$ at $P \leq 0.05$) between protein digestibility and tannin content of the samples. Tannins reduce protein digestibility (Adewusi and Falade, 1996). The protein requirement of a 10-year old child whose body weight is 22 kg has been estimated to be 0.8g/ kg body weight; daily requirement for that child would be approximately 18 g of protein. Thus, 100 g of the sample would provide approximately 80% of the daily protein requirement for children, if processed and consumed without altering the protein chemical structure. Based on the high protein content of watermelon seed, it can be incorporated into weaning diets and any protein deficient diets. 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).

The quality of plant foods depends not on only on the protein content but also on the proportion of essential amino acids. The amino acid composition of the samples is presented in Table 2. Samples of *C. lanatus* had higher content of essential amino acids compared to *C. colocynthis*. Tryptophan was not analyzed because it is known to be destroyed by acid hydrolysis (Falade and Adewusi, 2013). Arginine, glutamic and aspartic acids were the most abundant amino acids in all the samples with the highest values reported for 'Rothmas' watermelon. This observation contradicted the earlier report that the content of these amino acids was higher in 'Sugar Baby' compared to 'Rothmas' watermelon (Wani et al., 2011).

The essential amino acids such as lysine, leucine and isoleucine ranged from 2.77 to 3.13, 5.27 to 5.95, and 3.13 to 3.57 g·100 g^{-1} protein, respectively, while aromatic amino acids (tyrosine and phenylalanine) ranged from 7.83 to 8.33 g·100 g^{-1} protein. Cysteine was not found in watermelon cultivar 'Rothmas' and *C. colocynthis* but was detected in low quantity in 'Sugar Baby'. The amino acid scores showed that lysine (47 to 54%) is the limiting essential amino acid. In Nigeria, *C. colocynthis* seed is processed by fermentation to *ogiri* (a high flavoured enhanced food product) used as condiment for seasoning soup, in the same vein, *C. lanatus* due to its high glutamic acid content could be a valuable raw material in preparation of condiment and seasoning agent.

The content of carbohydrate (Table 1) was low (5.57-10.5%), indicating that watermelon seed contains more fats and proteins that are the nutrients needed for energy and body building. The reducing sugar (5.60 to 9.54 mg·g^{-1}) was lower than values reported for *acacia* seeds but similar to the values reported for some varieties of cowpea (Adewusi and Falade, 1996). The low content of reducing sugar means that watermelon seeds may not be as tasty as *Acacia* seeds, although sugar is not the only components of seed that produce taste.

The result of mineral content is presented in Table 3. The lower ash content reported for *C. colocynthis* is confirmed by its mineral content which had the lowest value for most of the minerals analyzed. There was no significant difference ($P \leq 0.05$) in the iron content of the both *egusi* melon and watermelon seeds. The values reported for iron were higher than the range of 55 - 70.9 and 29.9 - 53.3 mg·kg^{-1} respectively, reported for green beans and finger millet (Glew et al., 2008). Iron plays an important role in cellular metabolism especially in cellular respiration and in the transport of oxygen to the tissues (hemoglobin). Iron deficiency disease (anemia) is widely prevalent among children, adolescent girls and nursing mothers. Therefore, the consumption of watermelon seeds would be beneficial to the population at risk of anemia.

Copper and zinc ranged from 20.12 to 35.03 and 68.97 to 92.57 mg·kg^{-1}, respectively. Copper is essential cofactor for oxidation – reduction reactions involving copper containing oxidase, in the synthesis of collagen and for immune system (Guo et al., 2013), whereas zinc is required in the synthesis of nucleic acid

Table 2. Amino acid profile and amino acid scores (in parenthesis) of *Citrullis lanatus* (watermelon) and *Citrullus colocynthis* (*egusi* melon) seeds (g·100 g^{-1} protein)

Amino acid	*Citrullis lanatus*		*C. colocynthis*	Requirement*
	'Rothmas'	'Sugar Baby'		
Lys	2.77(0.47)	3.05(0.52)	3.13 (0.54)	5.8
Leu	5.95(0.85)	5.65(0.81)	5.27(0.75)	6.6
Ile	3.57(0.89)	3.48(0.87)	3.13 (0.78)	2.8
Cys*	ND	0.043	ND	
Met*	2.38(0.68)**	2.17 (0.63)**	2.08 (0.59)**	2.5
Phe**	4.76	4.35	4.17	
Tyr**	3.57(1.38)***	3.48(1.31)***	3.13(1.21)***	6.3
Thr	2.77 (0.69)	2.61(0.65)	2.61(0.65)	3.4
Val	3.97 (0.79)	3.48(0.69)	3.65(0.73)	3.5
His	2.38	2.17	2.08	1.9
Non-essential amino acid				
Arg	14.29	13.06	12.52	
Asp	6.75	6.09	5.74	
Gly	1.30	1.20	1.00	
Glu	16.67	15.67	14.61	
Pro	3.17	3.05	3.13	
Ser	4.36	3.91	3.65	

* - requirement for amino acid in preschool children (FAO/WHO, 1993)
** - Amino acid score was obtained by adding Met and Cys
*** - Amino acid score was obtained by adding Tyr and Phe
ND - Below detection limit
Values with the same superscripts across the rows are not significantly different according to Tukey's HSD test ($P \leq 0.05$)

Table 3. Mineral and water soluble vitamin content of *Citrullis lanatus* (watermelon) and *Citrullus colocynthis* (*egusi* melon) seeds

Parameters	*Citrullis lanatus*		*C. colocynthis*
	'Rothmas'	'Sugar Baby'	
Minerals (mg·kg^{-1})			
Magnesium	123.9 ± 0.52^{a}	94.79 ± 3.38^{b}	79.75 ± 7.65^{c}
Calcium	233.5 ± 16.39^{a}	125.9 ± 41.7^{b}	98.79 ± 3.83^{b}
Iron	211.3 ± 0.03^{a}	200.6 ± 1.24^{a}	191.3 ± 47.4^{a}
Copper	31.6 ± 0.050^{a}	35.03 ± 4.56^{a}	20.12 ± 6.16^{b}
Zinc	79.43 ± 8.78^{b}	92.57 ± 2.0^{a}	68.97 ± 3.47^{c}
Selenium	13.0 ± 0.05^{c}	28.0 ± 0.02^{a}	19.6 ± 0.03^{b}
Cadmium	0.07 ± 0.0002^{b}	0.1 ± 0.0001^{a}	0.008 ± 0.0001^{c}
Lead	0.06 ± 0.0009^{a}	0.09 ± 0.0001^{a}	ND
Vitamins (mg·100 g^{-1})			
Pyridoxin	3.2 ± 0.006^{a}	1.7 ± 0.01^{c}	2.6 ± 0.03^{b}
Thiamine	2.2 ± 0.08^{a}	1.1 ± 0.008^{c}	1.6 ± 0.01^{b}
Niacin	0.57 ± 0.11^{a}	0.33 ± 0.01^{b}	0.28 ± 0.001^{c}
Folate	0.9 ± 0.04^{a}	0.3 ± 0.05^{b}	0.4 ± 0.10^{b}
Ascorbic acid	ND	ND	ND

Mean ± standard deviation of triplicate analysis
Values with the same superscripts across the rows are not significantly different ($P < 0.05$)
ND- Below detection limit
Values with the same superscripts across the rows are not significantly different according to Tukey's HSD test ($P \leq 0.05$)

and protein (Ma and Betts, 2000). The content of calcium and magnesium ranged between 98.8 and 233.5, and from 79.8 to 123.9 mg·kg^{-1}, respectively. The values were lower than the values reported for finger millet. Calcium was reported to range from 3710 to 5230 mg·kg^{-1} while 1670 to 1830 mg·kg^{-1} was reported for magnesium (Glew et al., 2008). Calcium is essential for the growth, bone formation, blood coagulation, milk formation and vitamin D absorption. Rickets, osteomalacia and osteoporosis are deficiency diseases of calcium (Hassan et al., 2007). Magnesium on the other hand is known to be involved in energy metabolism and protein synthesis (Hassan et al., 2007).

The results obtained for heavy metals showed that the content of cadmium and lead were below the acceptable daily intake level. The acceptable levels for lead and cadmium are 0.21 - 0.25 and 0.06 - 0.07 mg/day, respectively (FAO/WHO, 1993). This shows that the consumption of watermelon seed is not likely to cause trace metal burden in the body.

The water soluble vitamin content of the samples are presented in Table 3. The vitamin content of 'Rothmas' was significantly higher ($P \leq 0.05$) than of other samples. The values obtained for thiamine, pyridoxine, niacin and folate were higher compared to soy product and buckwheat flour (Labiedzinska and Szefer, 2006). This shows that watermelon seeds could be better source of vitamins. The fact that watermelon seeds were similar with *egusi* melon seed implies that it could compliment *egusi* melon seeds as sources of vitamins. Ascorbic acid, a vitamin known for its antioxidant property was not detected in these samples. Most water soluble vitamins are unstable to heat and light as such the samples has to be handled with care especially during food processing.

The results of phytochemical screening are presented in Table 4. The results indicated that the seeds were positive for saponin and seemed not to contain alkaloids. Saponin has been reported to impair iron absorption and form complexes with cholesterol (Jacobberger, 2001).

Tannins have been reported to decrease protein digestibility and palatability (Jakobek, 2015). Tannin content ranged from 7.15 to 7.36 mg·g^{-1}, the value was not significantly different in the samples. The range obtained in this study was higher than 0.9 to 3.9 mg·g^{-1} reported for some Nigerian legumes (Adewusi and Falade, 1996) but lower than the range of 66.0 - 86.7 mg·g^{-1} reported for *Acacia* seeds (Falade et al., 2005).

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). Phytate content was significantly lower than 63.3 and 21.1 mg·g^{-1} reported for soybean and peanut (Megat-Rusydi and Azrina, 2012). The implication of these results reflects that this antinutritional compound is not likely to affect the nutritional value of these samples.

Cyanide which is known to cause neurodegenerative disease in human and animals is presented in Table 4. The levels of cyanide in all the samples were generally low (0.14 to 0.57 mg·g^{-1}) compared with the values reported for cassava and sorghum (Adundu et al., 2003). Oxalate has been implicated in the reduction of mineral availability (Al-Wahsh et al., 2005). The range of oxalate content (0.64 - 0.65 mg·100 g^{-1}) was significantly lower than the range of 0.67 - 3.5 mg·100 g^{-1} reported for soybean (Massey and Kynast-Gales, 2001). From the results obtained for anti-nutrients, it is evident that none of these samples could cause any nutrition disorders if consumed.

Conclusion

The findings of this study revealed that the chemical composition of watermelon (*C. lanatus*) compared favourably and even better for most of the nutritional parameters determined than egusi melon (*C. colocynthis*). *C. lanatus* seeds are potential sources of water soluble vitamins. On the other hands, *C. lanatus* showed higher content of anti-nutrients and heavy metals compared to *egusi* melon seeds. Although the levels of anti-nutritional compounds and trace metals were low and below the allowable limits. The glutamic acid content of *C. lanatus* was high, hence, it can be exploited for the production of condiment for seasoning foods. Therefore, consumption of watermelon seeds could help in combating protein-energy malnutrition and enhance food security.

Table 4. Anti-nutritional factors and phytochemical screening of *Citrullis lanatus* (watermelon) and *Citrullus colocynthis* (*egusi* melon) seeds

	Citrullis lanatus		*C. colocynthis*
Parameters	**'Rothmas'**	**'Sugar Baby'**	
Phytochemical screening			
Wagners	-ve	-ve	-ve
Tannic acid	-ve	-ve	-ve
Meyers	-ve	-ve	-ve
Saponins	+ve	+ve	+ve
Anti-nutrients			
Phytate (mg·g^{-1})	12.88 ± 0.28^{a}	12.53 ± 0.1^{a}	11.22 ± 0.19^{b}
Tannin (mg·g^{-1})	7.34 ± 0.10^{a}	7.36 ± 0.28^{a}	7.15 ± 0.28^{a}
Cyanide (mg·g^{-1})	0.57 ± 0.09^{a}	0.54 ± 0.33^{a}	0.14 ± 0.04^{b}
Oxalate (mg·100 g^{-1})	0.64 ± 0.00^{a}	0.64 ± 0.00^{a}	0.65 ± 0.00^{a}

Mean ± standard deviation of triplicate analysis

Values with the same superscripts across the rows are not significantly different according to Tukey's HSD test ($P \leq 0.05$)

References

Achu M.B., Fokou E., Tchiegang C., Fotso M. Tchouanguep F.M. (2005). Nutritive value of some Cucurbitaceae oilseeds from different regions in Cameroon. Afr. J. Biotechnol. . 4: 1329-1334.

Adewusi S.R.A., Falade O.S. (1996). The Effect of Cooking on Extractable Tannin, Phytate, Sugar and Mineral Solubility on some improved Nigerian Legume Seeds. Food Sci. Technol. Int. 24: 231-240.

Adewusi S.R.A., Falade O.S. Harwood C. (2003). Chemical composition of *Acacia colei* and *Acacia Tumida* seeds—potential food sources in the semi-arid tropics. Food Chem. 80: 187–195.

Adundu M.N, Olayemi F.F., Nze-Dike O.U. (2003). Cyanogenic potential of some cassava product in Portharcourt markets in Nigeria. J. Food Compos. Anal. 16: 21-24.

Al- wahsh I.A, Homer H.T., Palmer R.G, Reddy, M.B., Massey L.K. (2005). Oxalate and phytate content of soyfoods. J Agr Food Chem. 53: 5670-5674.

Anuebunwa F.O. (2000). A bio-economic on-farm evaluation of the use of sweet potato for complementary weed control in a yam/maize/egusi/cassava intercrop in pigeon pea hedgerows in the rain forest belt of Nigeria. Biol. Agric. Hort. 18: 95–102.

AOAC. (1984). Official methods of analysis (13th ed.). Arlington, VA, USA: Association of Official Analytical Chemists.

AOAC. (2000). Official methods of analysis of the Association of Official Analytical Chemists, 17th Edition, AOAC International, Gaithersburg MD.

Bainbridge Z., Tomlins K., Wellings K., Wetby A. (1996). Methods for assessing quality characteristics of non-starch staples. Part 3 Lab Manual, Natural Resource Institute 336: 93-104.

Batholomeo M.P., Maisano F (2006). Validation of a reversed phase HPLC for qualitative amino acid analysis. J. Biomol. Tech. 17:131-137.

Bressani R., Breuner M., Ortiz M.A. (1989). The nutritional composition of Australian Aboriginal bushfoods 3: Seed and nuts. Food Technol. Aust. 37: 375-379.

El-Safy F.S., Salem R.H., Abdel-Ghumy M.E. (2012). Chemical and Nutritional evaluation of different seed flour as novel sources of protein. World Journal of Dairy and Food Sciences 7: 59-65.

Essien E.B, Amaefule, O.I., Ihenacho E. (2009). Proximate Analysis and Physico-chemical properties of Watermelon (*Citrullis lanatus*) Seeds. Nigerian Journal of Biochemistry and Molecular Biology 24: 6-10.

Fagbemi T.N., Oshodi, A.A. (1991). Chemical composition and functional properties of full fat fluted pumpkin seed flour. Nigeria Food Journal 9: 26-32.

Falade O.S., Obushe V. (2014). Evaluation of physicochemical properties and total phenol content of watermelon (Rothmans and Sugar Baby) seed oils. Ife Journal of Science 16: 257-264.

Falade O.S., Adewusi, S.R.A. (2013). Comparative analysis of some essential amino acids and available lysine in *acacia colei* and *acacia tumida* seeds using chemical methods and amino acid analyzer. *JAOAC* 96: 102-109.

Falade O.S., Abolanle S.A, Mutalib A.A, Segun O.A, Harwood C., Adewusi S.R.A (2008). Physicochemical properties, total phenol and tocopherol of some acacia seed oils. J Sci. Food Agric. 88: 263-268.

Falade O.S, Owoyomi O., Harwood C.E, Adewusi S.R.A. (2005). Chemical composition and starch hydrolysis of *Acacia colei* and *Acacia tumida* seeds. Cereal Chem. 82: 479-483.

FAO/WHO, (1993). Composition and selected uses of fats and oils in food, in Report of the Joint FAO/WHO Expert Consultation on Fats and Oils in Human Nutrition, Rome, pp 5 - 27.

Glew R.S, Chuang L., Robert J.L, Glew H.A. (2008). Amino acid, fatty acid and mineral content of black finger millet (*Eleusine coracana*) cultivated on Jos Plateau of Nigeria. Food 2:115-118.

Guo C.H., Wang C.L (2013). Effect of zinc supplementation on plasma copper/zinc ratios, oxidative stress and immunological status on haemodialysis patients. Int. J. Med. Sci. 10: 79-89.

Gusmini G., Wehner T. C., Jarret R.L. (2004). Inheritance of Egusi Seed Type in Watermelon. Journal Hered. 95: 268–270. doi: 10.1093/jhered/esh031

Haque M.R, Bradury J.H. (2002). Total cyanide determination of plant and foods using the picrate acid hydrolysis methods. Food Chem. 77: 107-114.

Harland H.E, Oberleas, D. (1986). Anion exchange method for determination of phytate in foods Collaborative study. *JAOAC* 69: 667-670.

Hassan L.G., Umar, K.J., Umar, Z. (2007) Antinutritive factors in *Tribulus terrestris* (Linn) leaves and predicted calcium and zinc bioavailability. Journal of Tropical Bioscience 7: 33-36.

Jacobberger J.W. (2001). Stereochemistry of immune cytochemical staining reactions Methods. Cell Biol. 63: 271-198.

Jakobek L. (2015). Interactions of polyphenols with carbohydrates, lipids and proteins. Food Chem. 175: 556-567.

Khor S, Tee E. (1996). Development of a HPLC method for the simultaneous determination of several B-vitamins and Ascorbic Acid. Malawi Journal of Nutrition 2: 49–65.

Lebiedinska A., Szefer P. (2006). Vitamin B in grain and cereal-grain food, soy products and seeds. Food Chem. 95: 116-122.

Ma J., Betts N.M. (2000), Zinc and Copper Intakes and Their Major Food Sources for Older Adults in the 1994–96 Continuing Survey of Food Intakes by Individuals (CSFII). J. Nutr. 98: 2838-2842.

Massey L.K., Kynast-Gales S.A (2001). Diets with either beef or plant protein reduce risk of calcium oxalate precipitation in patients with a history of calcium kidney stones. J. Am. Diet. Assoc. 101: 326-331.

Megat Rusydi M.R., Azrina A. (2012). Effect of germination on total phenolic, tannin and phytic acid contents in soy bean and peanut. Int. Food Res. J. 19: 673-677.

Odebiyi O.O., Sofowora E.A. (1978). Phytochemical Screening of Nigerian medicinal plants II. Lloydia 41: 234-236.

Otemuyiwa I. O., Adewusi, S. A. (2013). Simultaneous high performance liquid chromatography analysis of water soluble vitamins in some foods prepared by a Nigerian eatery. Afr. J. Food Sci. 7: 415-420. doi: 10.5897/AJFS2013.1086

Pereira M.A., Kartashov A.I., Ebbeling C.B., Van Horn L., Slattery M.L., Jacobs D.R., Ludwig D.S. (2005). Fast food increases the risk of Obesity and Diabetes. Lancet 365: 36–42.

Price M.L., Scoyoc S.V., Butler L.G. (1978). A critical evaluation of the vanillin reaction as an assay for tannin in sorghum grain. J. Agric. Food Chem. 26: 1214-1218.

Van Soes P.J., Robertson J.B. Lewis B.A. (1991). Methods for dietary, neutral detergent fiber, and non starch polysaccharides in relation to animal nutrition. Symposium: carbohydrate methodology, metabolism, and nutritional implications in dairy cattle. J. Dairy. Sci. 74: 3583-3597.

Wani A.A, Sogi D.S., Singh P, Wani I.A., Uma S.S. (2011), Characterisation and functional properties of watermelon (*Citrullus lanatus*) seed proteins. J. Sci. Food. Agric. 91: 113-121.

Wu, H., Dywer K.M., Fan, Z., Anne S., Fan J., Dywer J.H. (2003). Dietary Fiber and progression of Arteriosclerosis: The Los Angeles Atherosclerosis Study. Am. J. Clin.. Nutr. 78: 1085-1091.

aCS85_5