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Nutritional Composition of Boiled and Unboiled Watermelon: A Comparative Study

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ABSTRACT

Background and Objective: Watermelon is consumed in various forms in Nigeria. It is either eaten raw or boiled as vegetables in foods. In Nigeria, only the fresh fruits of watermelon are consumed while the seeds are discarded. This study is aimed at ascertaining the effects of boiling on the nutritional profile of watermelon. **Materials and Methods:** Raw and cooked watermelon were used for this research work. Proximate, mineral and phytochemical screening of the raw and cooked watermelon were carried out and compared statistically. Data collected were subjected to One-way Analysis of Variance (ANOVA) and the treatment means were separated using Fisher's least significant difference at $p = 0.05$. **Results:** Proximate analysis results of the boiled and unboiled watermelon studied showed that the highest carbohydrate content was in the boiled watermelon (43.30±0.028) while the least carbohydrate content was found in the unboiled watermelon (30.58±.0.024). The highest protein content was found in the boiled watermelon (8.82±0.025) and the least was found in the unboiled watermelon (3.28±0.017). Ether extract (fat) was highest in the boiled watermelon (3.38±0.030) and lowest in the unboiled watermelon (1.36±0.028). Highest crude fiber content was found in the boiled watermelon (30.25±0.028) and the lowest crude fiber content was seen in the unboiled watermelon (10.10±0.011). Also, the unboiled watermelon had the highest moisture content (20.14±0.003) and the least moisture content was found in the boiled watermelon (9.89±0.028). **Conclusion:** Thus, it can be concluded that nutrients found in the fruits are in variable concentrations. Therefore, their consumption of unboiled watermelon is recommended for normal body function.

KEYWORDS

Citrullus lanatus, biosystematics, medicinal uses, pharmacology, toxicity, Cucurbitaceace

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INTRODUCTION

Water melon (*Citrullus lanatus*) of the family Cucurbitaceae is a common plant cultivated in Africa, Asia, Europe and America. It is cultivated on a large scale in Northern States of Nigeria such as Borno, Adamawa, Yobe and Taraba. It is an annual plant (herb), a climber that grows up to 3 m high occurring as an introduced cultivated plant throughout the West African Region[1,2]. They possess seeds although there are new varieties that are seedless.

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Research shows that there is a high increase in the consumption of watermelon in Nigeria, this is likely due to the recent increase in the sensitization and awareness of its nutritional and medicinal value. Watermelon is rich in carotenoids such as β-carotene, -carotene and lycopene which play an essential role in fighting and neutralizing free radicals in the body. Free radicals oxidize cholesterol in the body and make it stick to the walls of the blood vessels which can lead to heart attack. A review of extant literatures shows that consumption of carotenoids found in watermelon and other fruits such as tomatoes reduces the risk of some diseases such as arthritis and cancer etc[3].

Watermelon has low energy value and high vitamins and minerals such as vitamin K, vitamin C, riboflavin and iron[4]. It also contains a reasonable amount of proteins and fat and can be useful as a protein source in various food formulations and preparations[5]. Watermelon seeds are among the underutilized fruit by-products, though technologies exist for decorticating the seeds, only a small proportion of the seed is commercially processed while the remaining is discarded[6]. In some parts of Africa including Nigeria, only the fresh fruits of watermelon are consumed while the seeds are discarded.

However, it is on record that the seed is less than 5% while the pulp and the rind is about 70 and 26%, respectively. Over 70% of the weight of the seed is contributed by protein and fat. Hence it is grouped as oilseeds. In some countries, it is added to wheat flour used for bread production. It may also be used as a condiment, thickener in soups, fat binder and flavourant[5]. Traditionally, the seeds are removed from the rind and then allowed to dry outside in the sun, once dried, the seeds are then milled into flour. Many plant proteins usually in the form of protein extracts or seed flour have generated global attention in a quest to obtain new novel food products such as low-cost fabricated foods that are nutritionally rich, attractive and acceptable to consumers[7]. The ultimate success of utilizing plant proteins as ingredients largely depends upon the beneficial qualities, they have in foods which in turn depend largely on their nutritional and functional properties. This study aims to determine the nutritional composition of boiled and unboiled watermelon fruit.

MATERIALS AND METHODS

Study area: This study was conducted between October to December, 2023 in Awka, Anambra State, Nigeria. Awka has geographical coordinates of approximately Latitude 6°, 10" North and Longitude 7°, 04" East of Greenwich Meridian with a land area of about 4 km^2. Awka lies at an Altitude of 138 m above sea level. It has two marked seasons, the dry and wet seasons.

Preparation of samples for analysis: The fresh watermelon fruit 1 kg was bought from Nkwo Amenyi Market, Awka. The 1 kg plant samples (watermelon) were taken into the lab, washed and sterilized with 70% alcohol; the sample was peeled before blending with an electric blender (Silver Crest model:SC1589). Plant smoothy was used to carry out all the analysis required.

Preliminary phytochemical investigation: Quantitative phytochemical analysis of the raw and boiled water melon was carried out using standard method according to Trease and Evans[8] with little modifications. Some of the smoothies was boiled to boiling point and extracts was used.

Quantitative phytochemical investigation: The Follins-Dennis spectrophotometric method of Odeyemi *et al.*[9] was adopted in all quantitative phytochemical analysis.

Proximate analysis: Determination of proximate contents was done using different standard methods. The proximate contents of interest are crude protein, dry matter, ash, crude fiber, ether extract (fat), moisture content and carbohydrates.

Mineral content determination: The mineral content of the test samples was determined by the dry ash extraction method according to Anukwuorji *et al.*[10]. The 2.0 g of the samples were burnt to ashes in a Muffle furnace (200-1800°C) (Brother Furnace, Building 10, Henan National University Science and Technology Park, Zhengzhou, China) (as in ash determination). The resultant (resulting ash) was dissolved in 100 mL of dilute hydrochloric acid and then diluted to 100 mL in a volumetric flask using distilled water. The digest obtained was used for the various analysis.

Statistical analysis: The statistical analysis was carried out using GenStat Release 12.1 Software. Data were subjected to One-way Analysis of Variance (ANOVA). Fisher's least significant difference test ($p \leq 0.05$) was used to compare treatment means.

RESULTS

Proximate composition of the extracts of boiled and unboiled watermelon: The result of proximate composition of the extracts of boiled and unboiled watermelon was shown in Table 1. The table revealed that the boiled extract gave higher compositions of moisture (57.98±0.173%), crude fibre (3.14±0.030%) and carbohydrate (8.25±0.127%), while the unboiled extract gave higher compositions of dry matter (7.30±0.142%), ash (11.33±0.070%), ether extract (8.77±0.050%) and crude protein (2.22±0.029%). There was a significant difference in their composition in all the proximate assays between the extracts of boiled and unboiled watermelon ($p<0.05$).

Quantitative phytochemical composition of boiled and unboiled watermelon using different extracts: Results of quantitative compositions of the boiled and unboiled watermelon using different extracts are shown in Table 2 and 3, respectively. Table 2 revealed that aqueous extract gave highest compositions of all the phytochemicals which are saponin (14.17±0.042 mg/100 g), tannin (10.14±0.006 mg/100 g), phenol (16.20±0.021 mg/100 g), alkaloids (10.33±0.010 mg/100 g), steroid (3.27±0.060 mg/100 g), flavonoid (16.10±0.010 mg/100 g) and cyanogenic glycosides (3.15±0.006 mg/100 g). There was a significant difference in the composition of the boiled watermelon in all the phytochemicals assayed between the different extracts used ($p<0.05$).

Table 3 revealed that aqueous extract gave highest compositions of saponin (10.23±0.017 mg/100 g), tannin (12.14±0.005 mg/100 g), phenol (8.39±0.015 mg/100 g), alkaloid (3.20±0.015 mg/100 g) and cyanogenic glycosides (4.12±0.015 mg/100 g); ethanol extract gave highest composition of steroid (4.40±0.012 mg/100 g) while methanol gave highest composition of flavonoid (14.22±0.017 mg/100 g). There was a significant difference in the composition of the unboiled watermelon in all the phytochemicals assayed between the different extracts used ($p<0.05$). Table 4 compared the effects of the extraction medium on the phytochemical constituent of watermelon. Aqueous medium proved to be more effective in extracting most of the phytochemicals. For saponin, aqueous recorded the highest value (14.17±0.042 mg/100 g) while the least was observed from either (0.39±0.023 mg/100 g) although the p-values showed that the values were not significantly different from each other. A similar result was also recorded in tannin and phenol. For alkaloids, aqueous yielded the highest value (10.33±0.010 mg/100 g) while the least yield was obtained from methanol (1.85±0.017 mg/100 g) there were significantly ($p \leq 0.05$) different from each other. Ethanol had the highest value in steroid (4.40±0.012 mg/100 g) while aqueous recorded the highest yield in flavonoids and cynogenic glycosides with values 16.10±0.010 mg/100 g and 4.12±0.015 mg/100 g, respectively.

In comparison between each phytochemical of boiled and unboiled watermelon, there was a negative relationship in the steroid (-0.399) between the boiled and unboiled watermelon and this relationship was not significantly different. Every other relationship was positive but significant in the saponin, tannin and phenol compositions ($p<0.05$) (Table 5).

Table 1: Proximate composition of the extracts of boiled and unboiled watermelon

Specimen	Moisture content (%)	Dry matter (%)	Ash content (%)	Crude fibre (%)	Ether extract (%)	Crude protein (%)	Carbohydrate (%)
Boiled	57.98±0.173	4.18±0.070	8.25±0.122	3.14±0.030	4.19±0.172	0.19±0.020	8.25±0.127
Unboiled	40.06±0.212	7.30±0.142	11.33±0.070	1.32±0.035	8.77±0.050	2.22±0.029	2.19±0.042
p-value	0.000	0.003	0.004	0.035	0.002	0.011	0.000

Results are in Mean±Standard Deviation

Table 2: Quantitative phytochemical composition of boiled watermelon using different extracts

Extract	Saponin (mg/100 g)	Tannin (mg/100 g)	Phenol (mg/100 g)	Alkaloid (mg/100 g)	Steroid (mg/100 g)	Flavonoid (mg/100 g)	Cyanogenic glycosides (mg/100 g)
Ethanol	9.11 ± 0.119^{c}	9.47 ± 0.042^{c}	3.82 ± 0.012^{b}	2.33 ± 0.021^{b}	2.01 ± 0.099^{a}	10.19 ± 0.015^{a}	2.12 ± 0.015^{a}
Methanol	3.82 ± 0.020^{b}	8.37 ± 0.026^{b}	3.17 ± 0.026^{a}	1.85 ± 0.017^{a}	2.72 ± 0.012^{c}	10.35 ± 0.023^{b}	3.04 ± 0.038^{c}
Ether	0.39 ± 0.023^{a}	2.14 ± 0.012^{a}	10.73 ± 0.031^{c}	3.70 ± 0.139^{c}	2.18 ± 0.012^{b}	13.04 ± 0.025^{c}	2.34 ± 0.015^{b}
Aqueous	14.17 ± 0.042^{d}	10.14 ± 0.006^{d}	16.20 ± 0.021^{d}	10.33 ± 0.010^{d}	3.27 ± 0.060^{d}	16.10 ± 0.010^{d}	3.15 ± 0.006^{d}
p-value	0.000	0.000	0.000	0.000	0.028	0.015	0.041

Results are in Mean±Standard Deviation and means with the same letter in a column are not significantly different (p>0.05)

Table 3: Quantitative phytochemical composition of unboiled watermelon using different extracts

Extract	Saponin (mg/100 g)	Tannin (mg/100 g)	Phenol (mg/100 g)	Alkaloid (mg/100 g)	Steroid (mg/100 g)	Flavonoid (mg/100 g)	Cyanogenic glycosides (mg/100 g)
Ethanol	7.80 ± 0.012^{b}	10.14 ± 0.015^{b}	3.19 ± 0.061^{b}	2.84 ± 0.012^{b}	4.40 ± 0.012^{d}	8.13 ± 0.006^{a}	2.42 ± 0.038^{c}
Methanol	8.13 ± 0.012^{c}	12.39 ± 0.012^{d}	4.40 ± 0.015^{c}	3.13 ± 0.017^{c}	1.91 ± 0.006^{b}	14.22 ± 0.017^{d}	1.94 ± 0.000^{b}
Ether	5.22 ± 0.015^{a}	8.12 ± 0.015^{a}	2.17 ± 0.023^{a}	2.13 ± 0.012^{a}	1.42 ± 0.015^{a}	12.36 ± 0.021^{b}	1.36 ± 0.025^{a}
Aqueous	10.23 ± 0.017^{d}	12.14 ± 0.005^{c}	8.39 ± 0.015^{d}	3.20 ± 0.015^{d}	2.26 ± 0.010^{c}	13.41 ± 0.006^{c}	4.12 ± 0.015^{d}
p-value	0.000	0.000	0.000	0.034	0.017	0.000	0.020

Results are in Mean±Standard Deviation and means with the same letter in a column are not significantly different (p>0.05).

Table 4: Combined table of quantitative phytochemical composition of boiled and unboiled watermelon using different extracts

Extract	Saponin (mg/100 g)	Tannin (mg/100 g)	Phenol (mg/100 g)	Alkaloid (mg/100 g)	Steroid (mg/100 g)	Flavonoid (mg/100 g)	Cyanogenic glycosides (mg/100 g)
Ethanol	9.11 ± 0.119^{c}	9.47 ± 0.042^{c}	3.82 ± 0.012^{b}	2.33 ± 0.021^{b}	2.01 ± 0.099^{a}	10.19 ± 0.015^{a}	2.12 ± 0.015^{a}
Methanol	3.82 ± 0.020^{b}	8.37 ± 0.026^{b}	3.17 ± 0.026^{a}	1.85 ± 0.017^{a}	2.72 ± 0.012^{c}	10.35 ± 0.023^{b}	3.04 ± 0.038^{c}
Ether	0.39 ± 0.023^{a}	2.14 ± 0.012^{a}	10.73 ± 0.031^{c}	3.70 ± 0.139^{c}	2.18 ± 0.012^{b}	13.04 ± 0.025^{c}	2.34 ± 0.015^{b}
Aqueous	14.17 ± 0.042^{d}	10.14 ± 0.006^{d}	16.20 ± 0.021^{d}	10.33 ± 0.010^{d}	3.27 ± 0.060^{d}	16.10 ± 0.010^{d}	3.15 ± 0.006^{d}
Ethanol	7.80 ± 0.012^{b}	10.14 ± 0.015^{b}	3.19 ± 0.061^{b}	2.84 ± 0.012^{b}	4.40 ± 0.012^{d}	8.13 ± 0.006^{a}	2.42 ± 0.038^{c}
Methanol	8.13 ± 0.012^{c}	12.39 ± 0.012^{d}	4.40 ± 0.015^{c}	3.13 ± 0.017^{c}	1.91 ± 0.006^{b}	14.22 ± 0.017^{d}	1.94 ± 0.000^{b}
Ether	5.22 ± 0.015^{a}	8.12 ± 0.015^{a}	2.17 ± 0.023^{a}	2.13 ± 0.012^{a}	1.42 ± 0.015^{a}	12.36 ± 0.021^{b}	1.36 ± 0.025^{a}
Aqueous	10.23 ± 0.017^{d}	12.14 ± 0.005^{c}	8.39 ± 0.015^{d}	3.20 ± 0.015^{d}	2.26 ± 0.010^{c}	13.41 ± 0.006^{c}	4.12 ± 0.015^{d}
p-value	0.000	0.000	0.000	0.034	0.017	0.000	0.020

Values are mean scores ±Standard deviation of three replicates and Data in the same column bearing different superscripts significantly different (p<0.05)

Table 5: Paired correlation between phytochemicals of boiled and unboiled watermelon

Boiled and unboiled watermelon	N	Correlation	Significance
Saponin and saponin	12	0.897	0.000
Tannin and tannin	12	0.821	0.001
Phenol and phenol	12	0.622	0.031
Alkaloid and alkaloid	12	0.331	0.294
Steroid and steroid	12	-0.399	0.199
Flavonoid and flavonoid	12	0.417	0.177
Cyanogenic glycosides and cyanogenic glycosides	12	0.547	0.066

DISCUSSION

The inference of this study revealed that watermelon is rich in proximate and phytochemicals tested. Comparatively, the raw watermelon is richer than the cooked one in the nutrients tested except for moisture, crude fibre and carbohydrate. Proximate analysis is one of the basics of experiments in biological science and other related fields of study. Thus, it is significantly relevant in determining the percentage compositions of plant and their parts[11]. In this study, boiled and unboiled watermelon extracts were analyzed. It revealed significant compositions of moisture, crude fibre and carbohydrate in the boiled watermelon extract; and dry matter, ash, ether extract and crude protein in the unboiled watermelon extract.

This means that boiling watermelon increases moisture content which could be as a result of water used for boiling sipping into the cells of the watermelon, causing it to swell up and imbibe more moisture in the process. Thus, boiling reduces the shelf-life, quality and texture of watermelon which makes it more open to bacterial contamination during storage[12]. The increased crude fibre composition could have been caused by the denaturization of the chemical components of the watermelon through boiling, thereby releasing the natural binding properties that hold other fluids within the cells and leaving out the cellulose cell wall of the fruit. This means that boiled watermelon can prevent constipation by aiding in bowel movement. It may also help to lower cholesterol levels[13].

On the other hand, the higher compositions of dry matter, ash, ether extract and crude protein in the unboiled extract are their natural components not destroyed by heat. Thus, when unboiled watermelon is dried, it contains more dry matter and ash than when boiled. This makes unboiled watermelon a better livestock feed as more amount of nutrients in it are available to animals[13]. Higher crude protein in the unboiled watermelon implies that it has more immune function capabilities than boiled one[14]. This higher ether extract means when fed to animals could improve their reproduction performance considerably like higher conception rates[15]. The quantitative phytochemical composition revealed that aqueous extracts gave the highest compositions of saponin, tannin, phenol, alkaloid and cyanogenic glycosides in both boiled and unboiled watermelon; and of steroid and flavonoid in unboiled watermelon. Saponins are known to promote cardiovascular health due to their ability to lower cholesterol and body fat levels. They are also beneficial for body weight. Due to their hypoglycemic properties, they keep blood sugar levels within normal limits and prevent insulin spikes[16].

Tannins are known to accelerate blood clotting, reduce blood pressure, decrease the serum lipid level, produce liver necrosis and modulate immunoresponses[16]. This implies that aqueous extract and its method of extraction yields more results in determining the phytochemical composition of plant materials than the use of ethanol, methanol and ether extracts. Thus, the aqueous extraction method significantly affects the number of plant extracts, especially in experiments when small amounts of extracts are needed. Comparing phytochemicals by phytochemicals of boiled and unboiled watermelon, there was a positive relationship between the saponin, tannin and phenol. Implying that increased boiling or not boiling watermelon significantly increases the composition of saponin, tannin and phenol. However, there was a negative relationship in the steroid. This means that increased boiling of watermelon decreases its steroid composition. Steroids can ease inflammation and slow your immune system. They can treat many kinds of inflammatory conditions[16].

CONCLUSION AND RECOMMENDATIONS

It was discovered that boiling affects the phytochemical and nutritional constituents of watermelon. By application of heat, the little amount of crude protein present in watermelon is lost or reduced to simple carbohydrates. Thus, these recommendations are made from the study; watermelon and other plant parts should not be boiled before being used in phytochemical or nutritional (proximate) analysis to increase their shelf-life. When carrying out phytochemical analysis, aqueous extracts should be more preferable for better extraction (in quantity and quality). More research should be focused on the flavonoid content of watermelon, to know its antioxidant properties.

SIGNIFICANCE STATEMENT

Watermelon is an important fruit/vegetable in Nigeria and most of the countries across the globe. It is either eaten raw or processed before consumption. There is currently a dearth of information on the effects of processing especially heat on the nutritional composition of watermelon. The research was designed to compare the nutritional contents of raw and boiled watermelon to make recommendations to consumers and all other relevant stakeholders on the best to consume watermelon to get the maximum nutritional benefits. The findings of this research have bridged the information gap to the effects of processing on the nutrient contents of watermelon. From the information available it is recommended that the consumption of raw watermelon is preferred because processing treatments significantly reduce the chemical composition and nutritional profile of watermelon.

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