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Research Article
Physico-Chemical Properties and the Use of Watermelon (*Citrullus lanatus*) Seed as a Soup Thickener

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Abstract
Background and Objective: *Citrullus* spp. seeds are used as soup thickeners in most West African countries. They provide protein thereby solving protein malnutrition problem. *Citrullus lanatus* seed as a member of the family is usually discarded after the mesocarp has been consumed. The aim of the study was to investigate the potentials of watermelon seed (*Citrullus lanatus*) as a soup thickener. **Materials and Methods:** The watermelon seed was sundried, dehulled and ground into flour. The flour was subjected to chemical analyses using standard methods (AOAC). The anti-nutritional factors were analyzed using Pearson method. Functional properties were carried out according to the method of Onwuka. The watermelon seeds flour were prepared and evaluated using a 9-point Hedonic scale and data generated were subjected to one way analysis of variance. **Results:** The study revealed that watermelon seed contains high amounts of crude protein (24.33%), fat (28.27%) and fibre (4.33%). The seed is high in calcium (8.22 mg/100 g), Vitamin A (321.96 mg/100 g) and D (256.56 mg/100 g) respectively. The seed is low in anti-nutrients but has high water and oil absorption capacities (106.44 and 133.11%). There was no significant difference ($p>0.05$) between the soups prepared using watermelon and melon seeds. **Conclusion:** The study revealed that watermelon seed is high in nutrients and compared favourably with melon soup. Thus watermelon seed can serve as a soup thickener.

Key words: Calcium, fibre, mineral contents, protein, seed oil, sensory, soup thickener, vitamin A and D, watermelon seed

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Watermelon (*Citrullus lanatus*) is a crop of economic importance[1]. The fruit can be round, long or spherical in shape and has distinctive thick green rinds that are often spotted or stripped[2]. The fruit is made up of fruit coat, mesocarp and seeds. The mesocarp can be white, green, yellow, orange, pink, or red[3]. Watermelon seeds are excellent sources of protein, oil, dietary fibre, micro and macro-nutrients such as magnesium, calcium, potassium, iron, phosphorus, zinc, vitamins[4]. The seed is rich in omega 3 and omega 6 fatty acids. The high level of magnesium in watermelon seed has health benefits more especially maintaining the heart functions.

The seed can be roasted and consumed as snacks, ground into flour which has excellent functional properties that makes it desirable for baking[5]. The seed being an excellent source of energy makes it suitable as livestock feed[6]. The Oil from the seeds is used in cooking and is incorporated into the production of cosmetics[7]. Despite the various potential applications, the watermelon seeds are often discarded while the fruit is eaten.

The watermelon seeds and fruit coat which are discarded contribute to the volume of solid wastes and waste management is still facing a lot of challenges in the country. Harnessing food wastes utilization in diets could improve food supply, health and the environment[8]. In Nigeria, despite the fact that there is an increased demand for watermelon seed in the food industry as nutraceuticals and dietary supplement, there is little or no demand for watermelon seed. In order to make the utilization of watermelon seed attractive, its use in soup preparation becomes necessary as the Nigerian populace depend mostly on food consumed with soup. The utilization of watermelon seed in soup preparation will enhance the utilization of the seed and the benefits therein and at the same time minimize its contribution to wastes and environmental problems. Thus, this study aimed to evaluate the physico-chemical properties as well as the suitability of watermelon seeds as a soup thickener.

MATERIALS AND METHODS

Source of sample: The watermelon (*Citrullus lanatus*) seed used for this study was extracted from watermelon purchased from Abakpa Main Market in Abakaliki, Ebonyi State, Nigeria. Other ingredients such-as salt, maggi, fish, meat, palm oil, vegetables and onions that were used in the preparation of the soup were equally purchased from Abakpa Main Market Abakaliki, Ebonyi State. The study was conducted in the Department of Food Science and Technology Ebonyi State University.

Production of watermelon seed flour: The watermelon fruit was washed and cut open for seed extraction. The watermelon seeds that were extracted were washed and sun dried. Winnowing was done before the seeds were obtained and dehulled manually, then the dehulled seeds were ground into flour with the use of a mechanical blender (Binatone, model 402). The ground watermelon seed was packaged in a high density transparent polyethylene bag and stored under ambient temperature. This was used for the chemical and physical analyses as well as for soup preparation. Melon seed (*Citrullus vulgaris*) which was used as control was equally ground and packaged in the same way as the test sample.

Chemical analysis: The watermelon seed flour was analyzed for, proximate composition, minerals and vitamins using official methods of Association of Official Analytical Chemist[9]. The anti nutritional factors namely tannin, phytate, saponin, oxalate, trypsin inhibitor, hydrocyanic acid (HCN) and haemagglutinin (HAEM) were determined according to Pearson[10] methods of analyses.

Functional properties of watermelon seed flour: The water absorption capacity, oil absorption capacity, bulk density, swelling capacity and foaming capacity were determined using the method of Onwuka[11].

Preparation of soup from watermelon seed and melon seed (egusi): Meat, stock fish and smoked fish were washed and were boiled for 40 min and seasoned with salt, pepper, onion and maggi. These formed the stock for the cooking of the soups. The stock was divided into two equal portions. The ground watermelon seed and melon seeds were added to the separate stocks and were continuously stirred to avoid caking or forming lumps (Fig. 1 and 2). Then, they were allowed to boil for 15 min, oil and other ingredients were added and the vegetable (bitter leaf) was added last. The soups were then boiled for another eight 8 min before they were brought down.

Chemical analysis

Sensory evaluation: The method described by Ihekoronye and Ngoddy[12] was used. Twenty untrained panelists comprising staff and students of the Department of Food Science and Technology, Ebonyi State University, Abakaliki

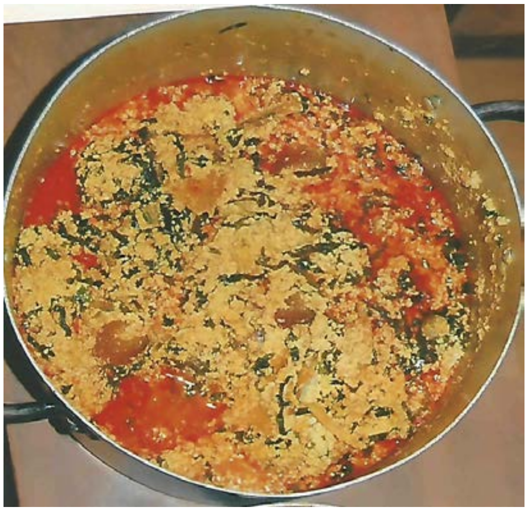

Fig 1: Watermelon seed soup

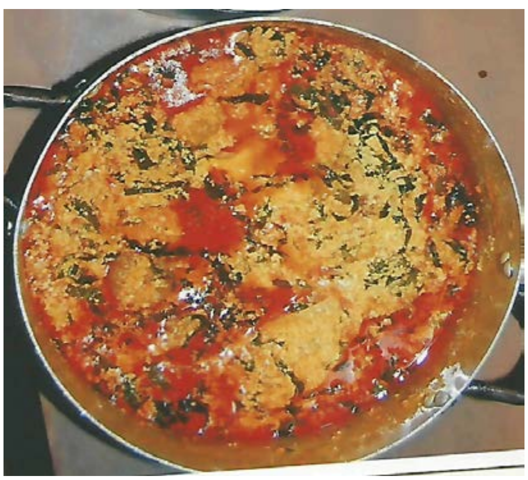

Fig 2: Melon seed soup

participated in this study. The soups were evaluated using a 9 point Hedonic scale where 1 represented dislike extremely, 9 represented like extremely and 5 represented neither like nor dislike. Attributes of interest like appearance, colour, flavour, taste and general acceptability were included. The soup samples were served with white saucers coded with 3 digit random numbers. Panelists were instructed to rinse their palates between samples during evaluation and their judgment was recorded on the score sheet.

Statistical analysis: Data were analyzed using one-way analysis of variance (ANOVA), followed by Duncan's Multiple-Range (DMR) test using the SPSS 20.0 Statistical Software Program (SPSS, Inc., IBM, Chicago, Illinois, USA). Differences of $p<0.05$ were considered statistically significant.

Table 1: Proximate composition of watermelon seed in percentages

Parameters	Mean±SD
Moisture	5.60±0.016
Protein	24.33±0.070
Fat	28.27±0.040
Ash	2.83±0.020
Crude fibre	4.30±0.030
Carbohydrate	34.67±0.070

Results are average of triplicate determinations±SD

RESULTS AND DISCUSSION

Proximate composition of watermelon seed: The result of the proximate composition of watermelon seed is presented in Table 1. The result revealed that watermelon seed flour is low in moisture. The moisture level of watermelon seed observed in this study (5.60) was lower than that reported by Ubbor and Akobundu[13] (9.79%). The lower the moisture contents of a product, the better the shelf stability of the product[14]. Therefore, the low moisture content of watermelon seed will enable it to be stored for a long period of time. The crude protein content of watermelon seed recorded in this study is lower than the values obtained for melon seed (36.50%)[15], bitter apple seeds (28.63%)[16], pumpkin seeds (27.48%)[17]. However, this study showed that watermelon seed contain high amount of crude protein and could contribute to the protein content of the diet of the consumer. Protein helps in growth, tissue repair, immune function, making essential hormones and enzymes, energy, preserving lean muscle mass and other functions[18]. The fat content was higher than the value obtained for shelled watermelon seed (17.36%)[19] but was lower than the value obtained for melon seed (49.00%)[15]. The high value of fat in watermelon seed could classify it as an oil seed and hence the oil could contribute to palatability of foods and as well source of energy and should be exploited for oil production. The ash content which is an indicator of the level of mineral in the seed shows that the seed could become a veritable source of minerals. Carbohydrate contents of the watermelon seed recorded in this study (34.67) is higher than that reported in a previous study (7.22%)[20]. This result shows that watermelon seed cannot be considered a potential source of carbohydrate however it can contribute meaningfully to the energy needs of the consumer since it will be consumed with other carbohydrate giving foods.

Vitamin content of watermelon seed: The result of vitamin content of watermelon seed is presented in Table 2. The vitamin A content of watermelon seed obtained in this study is higher than that reported by Egbuonu[8] (70.10 mg/100 g). This indicates that the consumption of watermelon seed will help in vision more especially people with impaired vision

Table 2: Vitamin content of watermelon seed

Parameters	Mean±SD
Vitamin B_1 (mg/100 g)	12.39±0.22
Vitamin B_2 (mg/100 g)	22.28±0.08
Vitamin B_5 (mg/100 g)	1.03±0.03
Vitamin B_6 (mg/100 g)	31.13±0.24
Vitamin C (mg/100 g)	11.21±0.06
Vitamin A (mg/100 g)	321.96±0.44
Vitamin E (mg/100 g)	256.56±0.26

Results are average of triplicate determination±SD

arising from night blindness. The vitamin B_1 content for watermelon seed recorded in this study was higher than that reported in a previous study by Egbuonu[8] (0.02 mg/100 g). This could be associated with varietal differences. The watermelon seed is a good source of vitamin B-complex with the exception of vitamin B_5. This implies that consumption of watermelon seed could prevent diseases resulting from low intake of vitamin B-complex. However, doses above 200 mg may cause urine alteration[21]. The result showed that watermelon seed is low in vitamin B_5 and as such supplementation from other food sources will be necessary to perform the needed function in the body. Vitamin B_5 is found in living cells as coenzyme A (CoA), which is vital for various numerous biochemical reactions. Vitamin B_5 helps to create red blood cells, create stress-related and sex hormones, maintain a healthy digestive tract, process other vitamins particularly B_2, synthesize cholesterol[22].

The ascorbic acid content of watermelon seed is low. Hence, supplementation from other food is required. High vitamin E content (256.56 mg/100 g) of watermelon seed implies that watermelon seed is a good source of vitamin E. Thus, consumption of soup prepared using watermelon seed could supply the recommended dietary allowance (RDA) in terms of vitamins A, B_1, B_2 and E.

Mineral content of watermelon seed: The mineral composition of watermelon seed is presented in Table 3. The mineral contents of the watermelon seed as reported in this study indicates that the seed is low in minerals indicating that it cannot provide the recommended daily allowance for the various minerals[21]. Oil seeds are not generally good sources of minerals. However, since the seed ordinarily is not consumed singly, low mineral content does not deter the use of watermelon seed as soup thickener. Besides, in soup preparation, many ingredients including vegetables are used, thus mineral deficiency may not be a problem in consuming such a soup.

Anti-nutritional composition of watermelon seed: The anti-nutritional composition of watermelon seed is presented in Table 4. The result shows that the seed is generally low in

Table 3: Mineral composition of watermelon seed (mg/100 g)

Parameters	Mean±SD
Phosphorus (P)	6.76±0.05
Calcium (Ca)	8.22±0.07
Iron (Fe)	2.81±0.07
Magnesium (Mg)	3.63±0.04
Zinc (Zn)	5.65±0.03

Results are average of triplicate determinations±SD

Table 4: Anti-nutritional composition of watermelon seeds (mg/100 g)

Parameters	Mean±SD
Tannin (mg/100 g)	15.215±0.02
Saponin (mg/100 g)	4.650±0.12
Oxalate (mg/100 g)	0.859±0.03
Phytate (mg/100 g)	0.320±0.01
Trypsin (mg/100 g)	2.910±0.03
Hydrogen cyanide (HCN) (mg/100 g)	0.086±0.00
Hemagglutinin (Heam) (mg/100 g)	0.987±0.00

Results are average of triplicate determinations±SD

anti-nutrients. Low levels of anti-nutrients indicate that the seed could be consumed without imposing some health challenges associated with high ingestion of anti-nutrients. Further processing during soup preparation will reduce some of the anti-nutrients and thereby enhance its use as a soup thickener. The saponin content is in agreement with a previous study[23]. The low trypsin and phytate levels increased protein and mineral absorptions. Cyanogenic glycosides present in watermelon seed are known to be toxic. Cyanogenic glycosides when enzymatically hydrolysed, release cyanohydrin acids known as prussic acid. This acid is extremely toxic due to its ability of linking with metals such as Fe^{2+}, Mn^{2+} and Cu^{2+} which are functional groups of many enzymes thereby inhibiting processes like reduction of oxygen in the cytochrome respiratory chain, electron transport in the photosynthesis and the activity of enzymes like catalase, oxidase[24]. Braide *et al.*[25] reported the presence of cyanogenic glycosides in the seeds of watermelon but at a very low percentage of 0.0023. They observed the saponins, alkaloids, flavonoids, oxalate and tannins in the seeds. Similar results were observed by Johnson *et al.*[26]. However, the level of cyanogenic glycoside in the present study cannot support toxicity as the soup preparation requires heat treatment which will further reduce the level of the cyanogenic glycoside in the seed.

Functional properties of watermelon seed: The functional properties of watermelon seed is presented in Table 5. The water absorption capacity (WAC)for watermelon seed recorded in this study was lower than that reported by Oyeleke *et al.*[27] (116.30%). WAC is important in foods where water will be imbibed without dissolution of protein, thus increasing their viscosity and body thickening[28]. The increase in WAC of watermelon seed flour may be attributed to the

Table 5: Functional properties of watermelon seed

Parameters	Mean±SD
Bulk Density (g mL^{-1})	0.400±0.01
Loose Density (g mL^{-1})	0.490±0.01
Water absorption capacity (%)	106.440±0.18
Oil absorption capacity (%)	133.110±0.18
Foam capacity (%)	8.870±0.01
Swelling capacity (%)	1.325±0.02

Results are average of triplicate determinations±SD

Table 6: Sensory scores of soup produced from watermelon seed and melon seed

Parameters	Melon seed soup	Watermelon seed soup
Taste	8.25±0.83[a]	7.75±0.99[a]
Appearance/consistency	8.25±1.04[a]	8.05±0.92[a]
Aroma	7.40±1.43[a]	7.50±1.20[a]
Overall acceptability	8.40±0.58[a]	7.70±1.19[a]

hydrophilic nature of protein that is present in watermelon seed which is increasing with a decrease in the starch content. This water absorption capacity will increase the volume of soup produced which is highly advantageous as this will increase the economic value. The oil absorption capacity for watermelon seed is higher than that reported by Oyeleke *et al.*[27]. Oil absorption capacity is critical in determining the flavour retention in food materials[27]. The high oil absorption capacity implies that watermelon seed will be able to retain more flavour and probably have better mouthfeel. The swelling capacity of the seed is low. The low swelling power of the watermelon seed flour may be attributed to presence of lipids in the watermelon seed which forms an insoluble amylose-lipid complex with amylose during swelling[29]. The bulk density of watermelon seed is lower than that of (0.71 g mL^{-1}) groundnut seed flour[30]. Bulk density is very important for dietary bulk and packaging requirements[31].

Sensory attributes of watermelon seed: The sensory scores of soup prepared from watermelon seed and melon seed are presented in Table 6. The sensory result revealed that there was no significant differences ($p>0.05$) between the soup samples. This implies that the watermelon seed though not commonly used as soup thickener possesses characteristics similar to melon seed which is commonly used as a soup thickener. The overall acceptability scores show that the watermelon seed could be substituted for melon seed in soup preparations.

CONCLUSION AND RECOMMENDATION

The study revealed that watermelon seed contain appreciable amount of nutrients, it can therefore be concluded that watermelon seeds can contribute significantly to our nutrient requirements. Besides, it is low in anti-nutrients. Thus, it is therefore recommended that awareness should be created among the populace on the utilization of watermelon seed as a soup thickener.

SIGNIFICANCE STATEMENT

The study revealed that watermelon seed contains high amounts of crude protein, fat, fibre, calcium, Vitamin A and D. The seed is low in anti-nutrients but high in water, oil absorption capacities and the nutrients compare favourably with that of melon seed. Thus, watermelon seed can serve as a soup thickener. This study will help researchers to uncover the critical areas of watermelon seeds utilization that many researchers were not able to explore. Thus, a new theory on the utilization of watermelon seeds may be developed.

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