

Nutritional And Phytochemical Quality Evaluation Of Sun-Dried White Portion Of Watermelon (Citrullus Lanatus) Rind: An Experimental Analytical Study

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ABSTRACT

Background: Watermelon rind (*Citrullus lanatus*) is an undervalued portion of the plant that is intensively being recognized as sustainable nutritional source with tremendous health advantages, despite being regarded as agricultural waste. The purpose of this study is to evaluate the proximate composition, mineral content, and phytochemical quality of sun-dried white portion of watermelon rind powder in order to ascertain its nutritional value. **Methods:** Fresh watermelon rind was collected and thoroughly washed. The white portion was separated, cut into small pieces, and sun-dried for three days. Then it was grounded into a fine powder and stored in an airtight container until further use. In dried sample proximate composition, mineral content and phytochemical quality were assessed through standard protocols. From mineral solution, selected minerals were assessed through Atomic Absorption Spectrophotometer (AAS). Phytochemical constituents (polyphenols and flavonoids) were estimated using spectrophotometric methods, and vitamin C was analyzed using DCPIP titration. **Results:** The rind powder was found to have 55.21g/100g of carbohydrates, 12.80g/100g of protein, and 9.43g/100g of crude fiber. The rind powder has a low-fat content of 0.64g/100g. The significant concentrations of potassium (3753.17mg/100g), calcium (425.20mg/100g), magnesium (271.31mg/100g), and iron (16.79mg/100g) in watermelon rind powder indicated its potential to help address mineral deficiencies. The moisture content and ash content was found to be 12.04g/100 g and 11.90g/100 g respectively. Phytochemical quality of rind powder was also found to be in noticeable extent. **Conclusion:** These results revealed that white portion of watermelon rind is embedded with appreciable amount of nutritional quality with phytochemical property.

Keywords: Watermelon rind, antioxidant, agricultural waste, nutritional value.

INTRODUCTION

The fruit watermelon (*Citrullus lanatus*) is a member of the Cucurbitaceae family and is high in nutrients. It is categorized under the genus *Citrullus*, order Cucurbitales, and kingdom Plantae. The Latin word "lanatus," which means woolly and refers to the fine hairs on the plant's stems and leaves, is the source of the name *Citrullus lanatus*. Widely consumed throughout India, watermelon is referred to by a number of regional names, including "Tarbooj" in Hindi, "Kallangadi" in Kannada, "Tharpoonsani" in Tamil, "Puchakaya" in Telugu, "Kalingad" in Marathi, "Tormuj" in Bengali, and "Tarbooj" in Gujarati. The fruit has a pale green inner rind and a thick, smooth outer rind that is usually green with

light green or gray streaks. Although certain species may have yellow flesh, the edible meat is typically red, juicy, and delicious. Depending on the kind, the implanted seeds might be white, brown, or black. Watermelon is composed of approximately 90–92% water, making it highly refreshing and hydrating. It is also a good source of vitamins, minerals, and antioxidants. ⁽¹⁾ According to historical evidence, watermelon farming began in Africa approximately 5,000 years ago, especially in ancient Egypt. ⁽²⁾

A member of the Cucurbitaceae family, watermelon is a nutrient-rich, refreshing fruit that contains more than 90–92% water, making it a great natural hydrator. It began more than 4,000–5,000 years ago in Africa, specifically in the Kalahari region.

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Watermelon's red shade and significant antioxidant qualities are attributed to its abundance of bioactive chemicals, especially carotenoids like lycopene. Along with trace levels of polyphenols and flavonoids, it also includes β -carotene, which adds to its health-promoting properties.⁽³⁾ Besides phytochemicals, watermelon provides a significant source of amino acids, particularly citrulline, which is prevalent in the rind and is metabolized in the body to L-arginine. These substances may enhance vascular function and are linked to increased nitric oxide generation.⁽⁴⁾ Along with important minerals like potassium and magnesium, watermelon is also a strong source of vitamins A and C. The white rind may help with digestion even though it has less nutritional fiber than the flesh. Additionally, the rind has less sugar than the pulp, which may help control the glycemic reaction when ingested. A variety of value-added products, including juices, smoothies, seed oil, and fermented goods like ethanol, can be made using watermelon. The rind can be used in pickles and functional food compositions, while the seeds are high in proteins and good fats. The bioactive substances found in watermelon, especially lycopene and citrulline, may help lower oxidative stress and inflammation, according to a number of studies. Frequent consumption has been linked to possible advantages for managing obesity, metabolic diseases, and cardiovascular health.⁽⁵⁾ However, more scientific evidence is needed to support assertions of direct impacts on lipid absorption (LDL/HDL). As compared to watermelon juice, the pomace (the residual pulp obtained after juice extraction) contains a more concentrated number of bioactive compounds such as lycopene, primarily due to reduced water content. This highlights the potential of watermelon by-products as valuable sources of functional ingredients. The nutritional and phytochemical makeup of watermelon, including its byproducts and processing waste, as well as the many methods used for dehydration, extraction, and chemical analysis, are the main topics of this review.⁽⁶⁾ The edible watermelon is a scrambling, trailing vine-like plant that is a member of the Cucurbitaceae family of flowering plants. With more than 1,000 recognized varieties that vary in size, shape, color, and seed content, it is extensively grown all over the world.⁽⁷⁾

Botanically speaking, the watermelon fruit is categorized as a pepo, a kind of berry distinguished by

its thick rind and lack of internal divisions. It is a juicy, sweet fruit that grows well in tropical and temperate regions. Though seedless variants are also extensively grown, the flesh is usually deep crimson or pink and has many black seeds. Although watermelon is frequently eaten raw, it can also be made into pickles, jams, juice, and blended drinks. Furthermore, the rind is edible and frequently pickled or fried in a variety of culinary uses. The Kordofan melons, which are indigenous to Sudan, are thought to be the closest cousins of cultivated watermelon. Wild watermelon species may have existed in North Africa, according to archeological data, including discoveries at the prehistoric site of Uan Muhuggiag in Libya that date to around 3500 BC. A complicated history of domestication has been revealed by more recent research (2022), which connected ancient seeds found in Libya to egusi-type watermelons found in West Africa, especially Nigeria. Before watermelon was more widely domesticated in Northeast Africa, Egypt is thought to have been among the first places where watermelon cultivation took place, with evidence going back to about 2000 BC. Based on traits like seed quantity, size, shape, rind pattern, and flesh color, watermelons are classified into more than 1,000 different kinds.⁽⁸⁾ The fruit can be spherical, oval, or oblong, and its rind can be pale or dark green, frequently with stripes or mottling. The colors of flesh range from orange, pink, and red to white and yellow. Due to international trade, watermelons are available all year round, but because they are refreshing, they are mostly eaten in the summer. Globally, consumption patterns have dramatically increased. For example, per capita consumption in the United States is estimated to be around 34.1kg per year and high consumption levels are also reported in nations like Tunisia. Fresh slices, fruit salads, juices, jams, jellies, and powdered concentrates are just a few of the many food products that use watermelons. Because of their nutritional and practical qualities, the rind and seeds are being used more and more in value-added goods. However, fresh watermelon whether whole, diced, or sliced is most frequently eaten in many areas.⁽⁹⁾ Hence the present study was undertaken with an objective to assess the nutritional quality and phytochemical quality of white portion of watermelon rind powder.

MATERIALS AND METHODS:

This study was an experimental analytical study. Fresh watermelon was purchased from the local market of Thimmanahalli, Tumakuru district, Karnataka, India. The samples were thoroughly washed to remove surface impurities, after which the outer peel was removed and white rind was separated. The separated rind was cut into small pieces and

subjected to sun drying for a period of three days. After complete drying, the rind was ground into a fine powder using a food mixer grinder. The powdered samples were then stored in airtight containers for further analysis. The processes of sample collection and sun drying were carried out in a batch-wise manner to ensure uniformity and consistency with at most care. The detailed parameters assessed in rind powder is shown in Figure 1.

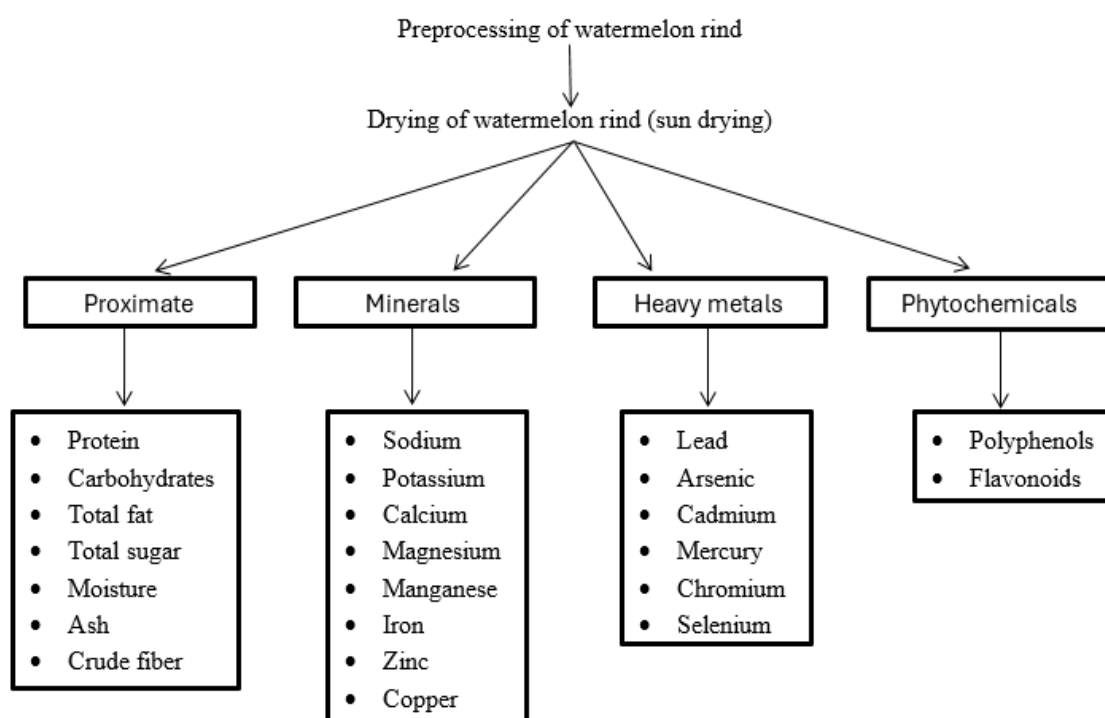


Figure 1: Flow design for nutritional and phytochemical quality evaluation

Estimation of moisture

A clean dry petri dish was kept in an oven at 105°C for 3 hours, cooled in a desiccator, and weighed (W_1). About 10g of sample was added and weighed (W_2). The sample was dried in the oven at 105°C for 3 hours, cooled, and reweighed (W_3).⁽¹⁹⁾

Moisture content was calculated as:

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

Estimation of Ash

Ash content of the sample was determined by incinerating the sample over a flame until complete burning was achieved. The residue obtained

represented the ash content and was expressed as g per 100g of sample.⁽¹⁹⁾

Estimation of Total Protein

Total protein content of the dried sample was estimated by determining the total nitrogen using the Micro-Kjeldahl method. The protein content was calculated by multiplying the nitrogen percentage by a conversion factor of 6.25 and expressed as g per 100g of sample.⁽²⁰⁾

Estimation of Fat

Fat content of the moisture-free sample was determined by extracting with petroleum ether. The solvent was then evaporated, and the remaining fat residue was weighed. The fat content was expressed as g per 100g of sample.⁽²¹⁾

Estimation of Crude Fiber

Crude fiber content of the sample was determined using a fat-free and moisture-free sample. The result was expressed as g per 100g of sample.

Calculation of Carbohydrates

Carbohydrate content of the sample was calculated by difference method.

$$\text{Carbohydrates (g/100g)} = 100 - [\text{Protein} + \text{Fat} + \text{Fiber} + \text{Ash} + \text{Moisture}]$$

Calculation of Energy

Energy content of the sample was calculated using standard conversion factors.

$$\text{Energy (kcal)} = [\text{Protein (g)} \times 4] + [\text{Carbohydrate (g)} \times 4] + [\text{Fat (g)} \times 9]$$

Estimation of Vitamin C

After homogenizing about 5g of the sample with 3% metaphosphoric acid, it was filtered. Using the same solution, the filtrate was increased to 100 milliliters. 2,6-dichlorophenol indophenol (DCPIP) dye was used to titrate a 10ml aliquot until a bright pink endpoint remained. The dye was titrated against DCPIP after being standardized using 5ml of 0.1mg/ml ascorbic acid combined with 5ml of 3%

metaphosphoric acid. The amount of vitamin C in the sample was measured in milligrams per 100 grams. ⁽²²⁾

Preparation of DCPIP Dye

Dissolve 50mg of DCPIP and 42mg of sodium bicarbonate in hot distilled water and make up the volume to 200ml. It was calculated by using the given formula:

$$\text{Dye factor} = \frac{0.5}{\text{Titre value}}$$

$$\text{Vitamin C (mg/100g)} = \frac{\text{Titre value} \times \text{Volume made up} \times 100}{\text{Weight of sample} \times \text{Volume taken}}$$

Mineral Estimation

Minerals such as iron (Fe), calcium (Ca), sodium (Na) and potassium (K) were assessed in white portion of watermelon rind. For minerals estimation, sun dried samples were incinerated in Muffle furnace at 550°C. Mineral solution was prepared by using diluted hydrochloric acid with 1:1 ratio. Further, minerals content was analyzed in prepared mineral solution through Atomic Absorption Spectrophotometer (AAS). The concentration of each mineral in sample is expressed in mg/100g.

Heavy Metals

Heavy metals were analyzed through Atomic Absorption Spectrophotometer (AAS). For analysis, 2g dry sample was digest on hot plate using 10ml of concentrated Nitric acid (HNO₃). Further filtrate was used for analyzing Lead, Arsenic, Cadmium, Mercury, Chromium, and Selenium using the respective standard stock.

Concentration was calculated by using the given formula:

$$\text{Concentration} = \frac{\text{ASS reading} \left(\frac{\text{mg}}{\text{L}} \right) \times \text{final volume (ml)}}{\text{Sample weight (g)}}$$

Estimation of Polyphenols (Folin-Ciocalteu method)

Spectrophotometric method was used to determine the sample's total polyphenol content. A UV-visible spectrophotometer was used to evaluate the color's intensity after the sample was removed and exposed

to color development. A standard curve was used to determine the concentration of polyphenols with 760nm wavelength. Gallic acid was used as standard for curve development. Further result was expressed in Gallic Acid Equivalent (GAE) per gram of sample. (23)

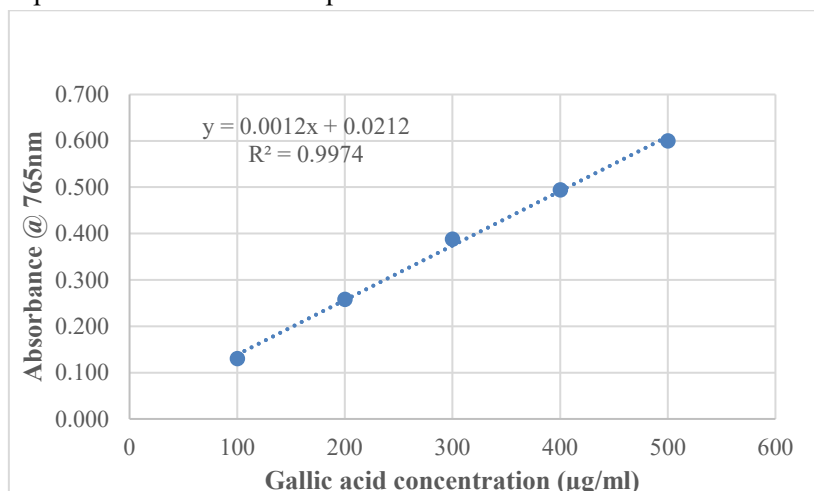


Figure 2: Standard curve for Polyphenols

Estimation of flavonoids

Dried sample was extracted in 80% methanol (1g sample in 10–20mL methanol) and further filtrate was used for flavonoids estimation. A UV-visible spectrophotometer was used to measure the

absorbance of the sample and standard at 510nm wavelength. Results were expressed in milligrams of Quercetin Equivalent (QE) per gram of dry material. (24) A standard curve was used to calculate the flavonoid content.

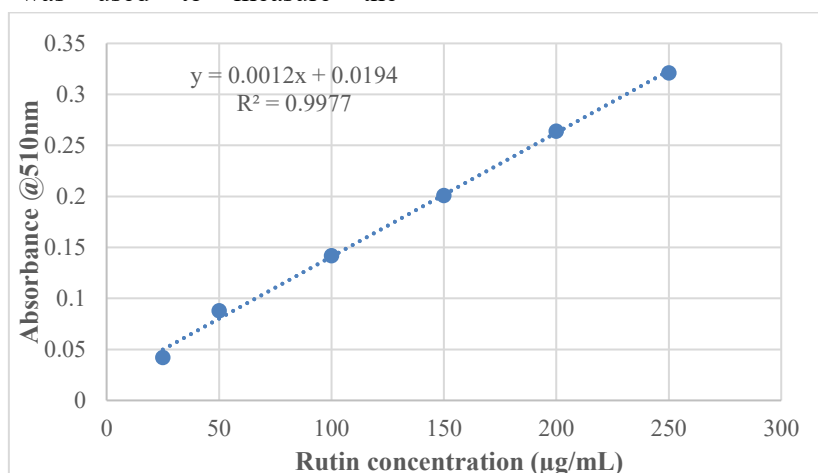


Figure 3: Standard curve for Flavonoids

RESULTS AND DISCUSSION:

Proximate parameters	Value ± SD
Energy (Kcal)	277.8
Protein (g)	12.80 ± 0.75

Carbohydrate (g)	55.21 ± 0.56
Total Fat (g)	0.64 ± 0.08
Total Sugar (g)	16.09 ± 0.50
Moisture (g)	12.04 ± 0.21
Ash (g)	11.90 ± 0.42
Crude Fiber (g)	9.43 ± 1.23

Table 1: Proximate composition of sundried white portion of watermelon rind powder

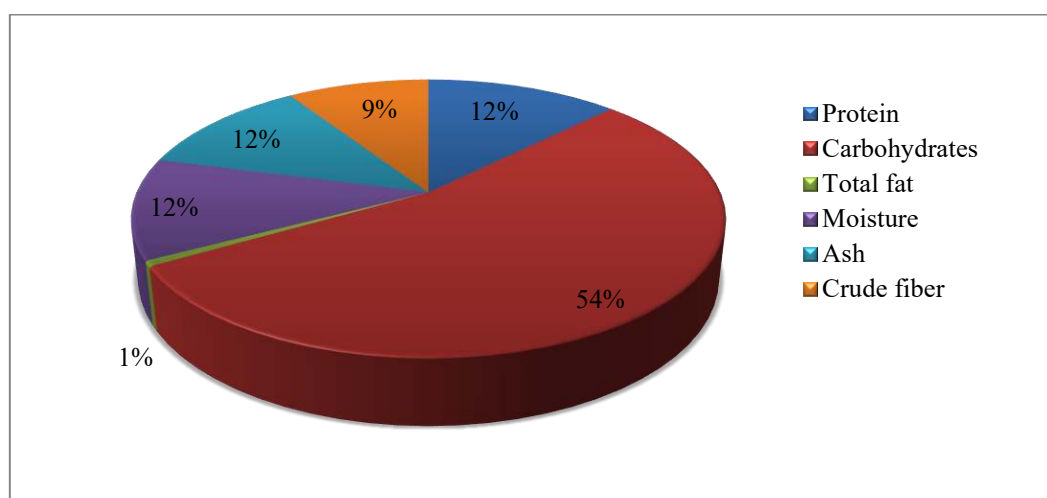


Figure 4: Proximate composition of sundried white portion of watermelon rind powder

The proximate composition of sundried white portion of watermelon rind powder is presented in table 1. It indicates that white portion of watermelon rind powder is nutrient-rich byproduct with potential value for human consumption or incorporation into food products.⁽¹⁰⁾ It has a moderate energy value (277.8kcal/100g) and is particularly notable for its high carbohydrate (55.21g/100g) and protein content was found to be 12.80g, suggesting it could serve as a good plant-based protein and energy source.⁽¹¹⁾ Additionally, the high crude fiber content (9.43g/100g) highlights its potential benefits for digestive health and dietary fiber enrichment. Similar result for proximate content was presented in the study conducted by Ashok *et al.*, 2022.⁽¹²⁾ The

powder contains low total fat (0.64g/100g). Total sugar content in white portion of watermelon rind powder was found to be 16.90g/100g making it suitable for low-fat dietary formulations. The moisture content (12.04g) is within acceptable limits for dried products, ensuring shelf stability. A significant ash content (11.90g) suggests the presence of minerals.⁽¹¹⁾

Overall, sundried white portion of watermelon rind powder demonstrates potential as a functional ingredient in food products, offering both nutritional and health-promoting properties while contributing to waste reduction and sustainable food practices.

Mineral parameters	Value ± SD
Sodium (mg)	239.25 ± 0.021
Potassium (mg)	3753.17 ± 6.80

Calcium (mg)	425.20 ± 5.58
Magnesium (mg)	271.31 ± 2.11
Manganese (mg)	0.71 ± 0.06
Iron (mg)	16.79 ± 0.45
Zinc (mg)	1.81 ± 0.11
Copper (mg)	0.29 ± 0.10

Table 2: Minerals composition of sundried white portion of watermelon rind powder

The Minerals composition of sundried white portion of watermelon rind powder is presented in table 2. It demonstrates that watermelon is a rich source of essential macro and micro minerals, contributing to its nutritional value and potential as a functional food ingredient. The powder contains a notably high level of potassium (3753.17mg/100g), which is vital for maintaining fluid balance, nerve function, and muscle health. Calcium (425.20mg/100g) and magnesium (271.31mg/100g) are present in appreciable amounts, supporting bone health and enzymatic functions. The sodium content (239.25mg/100g) is moderate, making it suitable for most dietary needs. Among trace minerals, the powder is a good source of iron

(16.79mg/100g), important for oxygen transport and reducing the risk of anemia. ⁽¹³⁾ It also contains zinc (1.81mg/100g) and manganese (0.71mg /100g), essential for immune function and antioxidant defense. Copper (0.29mg/100g), though lower, plays a role in iron metabolism and connective tissue formation. Overall, the high mineral content, especially potassium, calcium, magnesium, and iron, makes sundried white portion of watermelon rind powder a nutrient-dense and valuable addition to food formulations, with potential health benefits and applications in addressing mineral deficiencies. ⁽¹⁴⁾ Similar result for proximate content was presented in the study conducted by Ashok *et al.*, 2022. ⁽¹²⁾

Heavy Metals	Value
Lead (mg)	BLQ (LOQ 0.01)
Arsenic (mg)	BLQ (LOQ 0.01)
Cadmium (mg)	BLQ (LOQ 0.01)
Mercury (mg)	BLQ (LOQ 0.01)
Chromium (mg)	BLQ (LOQ 0.01)
Selenium (mg)	BLQ (LOQ 0.01)

Table 3: Heavy metal analysis of sundried white portion of watermelon rind powder

Table 3 represents the heavy metal analysis of sundried white portion of watermelon rind powder. It reveals that all tested heavy metals like lead, arsenic, cadmium, mercury, chromium, and selenium were below the limit of quantification (BLQ) at 0.01mg/100g. These results suggest that sundried white portion of watermelon rind powder is safe for

human consumption from a heavy metal contamination standpoint, aligning with international food safety standards. The absence of detectable toxic metals enhances the potential of this powder as a safe, sustainable, and nutritious ingredient in food and nutraceutical applications.

Parameters	Watermelon rind powder
Methanolic extraction yield %	46.36
Total polyphenols (mg GAE/g)	110.3
Total Flavonoids (mg QE/g)	14.75
Vitamin C (mg/100g)	335

Table 4: Phytochemicals analysis and Vitamin C content of watermelon rind

Table 4 represents the phytochemicals analysis and vitamin C content of white portion of watermelon rind powder. Methanolic extraction was found to be 46.36. With a total level of 110.3mg GAE per gram, the extract was high in polyphenols, indicating an important presence of these advantageous substances. A flavonoid content of 14.75mg QE per gram of extract was found. Unfortunately, it was not possible to determine or specify the saponin content of this sample due to analytical limitations. All things considered, the results show that the extract has significant concentrations of flavonoids and polyphenols, which may contribute to its possible health benefits. ⁽¹⁵⁾ Vitamin C was found to be 335mg per 100g of the sample. This indicates that the rind powder is a rich source of vitamin C, making it potentially beneficial for immune support, antioxidant defense, and collagen synthesis when used in food formulations or nutraceutical applications. ⁽¹⁰⁾

CONCLUSION

The analysis done on the sundried white portion of watermelon rind powder verifies that it is a nutritious and an agro-food byproduct, safe for consumption, with potential applications related to food and health uses. The proximate composition features fortify the claim that it could be useful in terms of providing additional dietary supplementation or as an ingredient specifically developed for energy, protein enriched food products. Furthermore, it has low fat and high crude fiber making it ideal for health concerned low fat, high fiber diets that promote digestion, support metabolic function, and ultimately improve overall health. The moisture content of ensures the stability of the product while the ash content indicates the high potent mineral value. ⁽¹⁶⁾

The minerals perform essential functions such as signaling, muscle contraction, bone structure maintenance, oxygen carrying, and immune system operating. Empirically, the nutrition value is boosted by the presence of certain elements such as Zinc, copper and manganese, the overall balance of minerals certainly makes the powder effectively utilized when marketed for functional health food and dietary supplementation, particularly in places with high susceptibility to mineral deficiency.

The powder is aligned to global standards of safety in food alongside absence of heavy metals poisoning risks. ⁽¹⁷⁾

Food systems can foster sustainability and reduce waste by incorporating sundried white portion of watermelon rind powder, thus promoting agricultural waste utilization. It conforms to developments in the sustainable food movement and circular economy models. ⁽¹⁸⁾

DECLARATIONS OF ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study did not involve human participants, animals, or identifiable human data; therefore, ethical approval was not required.

CONSENT FOR PUBLICATION

Not applicable

AVAILABILITY OF DATA AND MATERIALS

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

DECLARATION OF CONFLICTING INTEREST

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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AUTHORS' CONTRIBUTIONS

All authors contributed equally to the work, approved the final version of the manuscript, and take full responsibility for its accuracy and integrity.

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AI DISCLOSURE STATEMENT

ChatGPT (OpenAI) was used to assist with language editing, grammar correction, and manuscript preparation. All scientific content, interpretation of results, and final manuscript revisions were performed and verified by the authors, who take full responsibility for the published work.

LIST OF ABBREVIATIONS:

AAS – Atomic Absorption Spectrophotometer

AOAC – Association of Official Analytical Chemists

BLQ – Below Limit of Quantification

DCPIP – 2,6-Dichlorophenol Indophenol

FAO – Food and Agriculture Organization

GAE – Gallic Acid Equivalent

LOQ – Limit of Quantification

QE – Quercetin Equivalent

SD – Standard Deviation

UV – Ultraviolet

WHO – World Health Organization

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