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Research Article

Effect of Roasting on Functional Properties, Phytochemical Composition and Antioxidant Activity of Watermelon Seed Flour

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ABSTRACT

Background: Watermelon seeds are byproducts of watermelon with significant nutritional, therapeutic and functional potentials but they are often discarded as waste. The present study analyzed the effect of roasting on the functional properties, phytochemical contents and antioxidant activity of watermelon seed flour. **Materials and Methods:** Flour made from both dried, deshelled, roasted and unroasted watermelon seeds were analyzed for functional properties, phytochemical contents and antioxidant activity respectively. **Results:** The results revealed that roasting brought about a reduction in antioxidant activity as well as phytochemical contents such as alkaloid, saponin and flavonoid. However, the roasted watermelon seed flour exhibited a significant increase in the functional properties such as water absorption capacity and oil absorption capacity compared to the unroasted watermelon seed flour. **Conclusion:** Thus, these findings indicate that roasting reduces some health-promoting compounds but at the same time improves the flour's functional properties, thereby making it more suitable for food formulations that require better binding, moisture retention, and oil absorption.

Keywords: Antioxidant activity, Functional properties, Phytochemical composition, Watermelon seed flour.

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INTRODUCTION

Watermelon (*Citrullus lanatus*) belongs to the Cucurbitaceae family which is a widely consumed fruit and a horticultural crop grown majorly in tropical and subtropical areas. The watermelons can vary in size, shape as well as color and are of various varieties found in the markets. It is rich in nutrients and has great nutraceutical potentials and medicinal properties.[1] Beyond the fruit pulp, watermelon produces several byproducts which can be very useful for human use which are still not very well known; however, many recent studies are highlighting the importance of the by-products like the seed and rind for its use for various purposes.

Watermelon seeds are dicotyledons and consist of three main parts namely the endosperm, the embryo, and the seed coat. All the parts are important for the germination of the seed. The embryo develops into a new plant while the endosperm supplies the nutrients for its growth and the seed coat serves as a protective shield against external damage.[2] Traditionally, these seeds were discarded as a waste but now becoming popular as functional ingredients in food and pharmaceutical applications. Watermelon seeds are rich in nutrients like protein, fat, fiber, vitamins and minerals.[3] The nutritional value of these seeds are further enhanced by the presence of amino acids namely glutamic acid, arginine, serine and aspartic acid.[4] Additionally, they contain bioactive compounds such as saponins, alkaloids, tannins, glycosides as well as flavonoids and are rich in antioxidants.[5,4] Their phenolic and flavonoid content also contributes to antioxidant and anti-inflammatory activities.[6] Moreover, watermelon seed can be used to extract oil which is rich in unsaturated fatty acids like oleic and linoleic acids, thereby contributing to cardiovascular and metabolic health.[7]

The functional properties of watermelon seed flour such as its water absorption, oil absorption, emulsification, and binding capacities make it suitable for incorporation into food systems where it improves product consistency, texture and stability.[8] Watermelon seed is also getting popularized as a good alternative to many snacks and used as thickeners, binding agents, supplements, condiments and much more like an alternative to gluten in bakery foods or in making meat formulations.[7] Because of these properties, watermelon seeds have been explored for diverse applications ranging from snack foods and bakery formulations to herbal remedies for conditions such as

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diabetes, arthritis, inflammation, ulcers, cardio related problems, nephropathy conditions and urinary tract infections.[4,9] Watermelon seeds continue to be discarded as waste despite many benefits. There is limited literature addressing the comparative functional, phytochemical, and antioxidant properties of roasted and unroasted watermelon seed flours. By understanding these properties, watermelon seeds can be utilized as a sustainable and value-added food ingredient with its full potential. Therefore, the present study was undertaken to evaluate roasted and unroasted watermelon seed flour with specific focus on functional properties namely, Water Absorption Capacity (WAC) and Oil Absorption Capacity (OAC), phytochemical composition and antioxidant activity. The findings aim to provide insights into the enhancement of watermelon seed flour for novel food product development and thereby reducing wastage of watermelon seeds.

MATERIALS AND METHODS

Preparation of watermelon seed flour

Dried, deshelled watermelon seeds were purchased from the local market in Ernakulam district, Kerala, India. The seeds were manually sorted in order to remove the damaged and broken ones. A portion of the seeds were roasted until golden brown and was allowed to cool at room temperature while another portion was retained unroasted. Both roasted and unroasted watermelon seeds were ground separately using an electric grinder to obtain a fine flour. Both the flour were separately packed in sealed polythene covers and stored at room temperature until further analysis.

Analysis of the functional properties

The functional properties of both roasted and unroasted watermelon seed flours such as oil absorption capacity and water absorption capacity were analyzed by using a centrifuge. The functional properties describe the characteristics of food ingredients during preparation and cooking, as well as their effects on the appearance, texture, structure, and flavor of the final product.[10]

Water Absorption Capacity (WAC)

The Water Absolution Capacity of the WSF was analyzed by.[11] The flour was measured accurately as the requirement and the experiment was carried out. The result was calculated and expressed as percentage (%).

Oil Absorption Capacity (OAC)

The Oil Absorption Capacity of the WSF was analyzed in accordance with.[12] Groundnut oil was used for the experiment, the watermelon seed flour was measured accurately as the requirement and the experiment was performed. The results were calculated and expressed as percentage (%).

Determination of antioxidant activity

The antioxidant activity of roasted and unroasted watermelon seed flours was assessed using the 2,2-Diphenyl-1-Picrylhydrazyl (DPPH) radical scavenging assay following the method of.[13] Antioxidant activity was calculated and expressed as percentage inhibition (%).

Analysis of phytochemical contents

Roasted and unroasted watermelon seed flour were analyzed for their phytochemical contents such as saponins, alkaloids and flavonoids. The analysis was carried out using the SOP method (IS 3025-1964, IS 538:2000).[14,15] The phytochemical contents were quantified and expressed in mg/g.

Statistical analysis

Data obtained were analyzed to determine significant differences between roasted and unroasted watermelon seed flour using a paired samples *t*-test with the OPSTAT statistical software package. The statistical outcome was reported as *t* value along with the corresponding level of significance (*p* value). A $p<0.05$ was considered statistically significant.

Ethical statement

There was no requirement of any ethical approval for this study. The study was conducted using commercially purchased watermelon seeds and all experiments were based on it.

RESULTS

Functional properties of watermelon seed flour

Functional properties play a pivotal role in determining the texture, consistency, flavour and palatability of food products. They are important in food formulation as they determine quality, uniqueness and overall acceptability of the product. In this study, the functional properties particularly, Water Absorption Capacity (WAC) and Oil Absorption Capacity (OAC) of roasted and unroasted watermelon seed flour were assessed and compared to evaluate the difference in the flour's functionality. The results pertaining to functional properties of roasted and unroasted watermelon seed flour are presented in Table 1.

The WAC of roasted watermelon seed flour was 11.3% while unroasted watermelon seed flour was 8.66%. Similarly, the OAC of roasted and unroasted watermelon seed flour were 27.2% and 21.5% respectively. Statistical analysis showed that both parameters exhibited significant differences ($p<0.05$) between the roasted and unroasted watermelon seed flour. The '*t*' values for WAC and OAC were 25.0564 ($p=0.0016$) and 66.1439 ($p=0.002$) respectively. Thus, the results demonstrate a significant effect of roasting on both water and oil absorption capacities.

Phytochemical composition of watermelon seed flour

The phytochemical composition of roasted and unroasted watermelon seed flour was evaluated to determine the effect of heat treatment. The RWSF and URWSF varieties showed significant differences ($p<0.05$) in the phytochemical analysis and the results are displayed in Table 2.

Roasting significantly influenced the levels of saponins, alkaloids, and flavonoids in watermelon seed flour. The saponin content of Roasted Watermelon Seed Flour (RWSF) was 4.7 mg/g and Unroasted Flour (URWSF) was 11.62 mg/g, showing a significant decrease (t = -41.3973; p=0.006). Likewise, the alkaloid content decreased markedly from 47.2 mg/g in URWSF to 21.3 mg/g in RWSF (t = -156.4006; p=0.0000). The flavonoid content also reduced from 3.51 mg/g in URWSF to 1.8mg/g in RWSF (t = -37.6655; p=0.0007). These findings indicate that roasting caused a significant reduction in the major phytochemical constituents of watermelon seed flour.

Antioxidant activity of watermelon seed flour

Antioxidants are compounds that scavenge free radicals in the body and prevent damage caused by oxidative stress. The watermelon seed is known for its richness in antioxidants. The RWSF and URWSP varieties showed significant difference ($p<0.05$) in the antioxidant activity and the results pertaining to the antioxidant activity is presented in Table 3.

The antioxidant activity of Roasted Watermelon Seed Flour (RWSF) was 12.4%, and Unroasted Watermelon Seed Flour (URWSF) was 31.2%. Statistical analysis showed a highly significant difference between the two samples (t = -108.4761; p=0.001). The antioxidant activity value of URWSF obtained in this study aligned with the outcomes reported by.[16] However, the findings reveal that roasting significantly reduces the antioxidant activity of watermelon seed flour.

DISCUSSION

Functional properties of watermelon seed flour

Roasting significantly influenced the functional properties of watermelon seed flour. The WAC and OAC of roasted watermelon seed flour were higher when compared to unroasted watermelon seed flour. The observed increase in WAC might be due to protein denaturation induced by heat treatment during roasting, which exposes more polar amino acid residues capable of binding water. Moreover, the presence of mucilage, starch gelatinisation and swelling of fibre during roasting enhance the availability of hydrophilic sites, thereby contributing to greater water absorption capacity.[17]

Similarly, the enhanced OAC of roasted watermelon seed flour may be attributed to the protein denaturation which leads to the exposure of hydrophobic groups which interact with hydrocarbon chains of oil, thereby increasing oil absorption capacity.[17]

The present findings are in line with previous studies on other seeds. Roasted flaxseed powder showed higher WAC and OAC compared to its unroasted counterpart.[18] Likewise, it was reported that roasting chia seeds at 180°C for 35 min significantly improved their physico-chemical properties, especially water and oil absorption capacities.[17]

The findings of the present study suggest that roasting enhances the functional potential of watermelon seed flour, making it more suitable for incorporation in food formulations where improved binding, water and oil-absorption properties are desirable. Such improvements may have practical applications in bakery, meat analogues and snack products, thereby contributing to better texture, flavor and overall product quality.

Phytochemical composition of watermelon seed flour

Phytochemicals are naturally occurring bioactive compounds in plants that exhibit nutraceutical properties and provide therapeutic effects, thereby promoting health and preventing diseases. In the present study, both roasted and unroasted watermelon seeds were analyzed for their phytochemical constituents such as saponins, alkaloids and flavonoids.

Alkaloids are nitrogenous organic compounds present in plants with hepatoprotective, immunomodulatory, antioxidant, anticancer, antidiabetic, anti-inflammatory, anti-microbial and anti-malarial potential.[19] Saponins are naturally occurring plant glycosidic compounds which are known for their hypoglycaemic, hypolipidemic, antioxidant, anti-hypertensive, anti-asthmatic and anti-microbial activities.[20] Flavonoids are polyphenolic compounds present in plant pigments which exhibit therapeutic potential such as immunomodulatory, antioxidant, anticarcinogenic, antidiabetic, anti-inflammatory and antiproliferative properties.[21]

The roasted watermelon seed flour exhibited a noticeable reduction in the in the levels of saponins, alkaloids and flavonoids compared to the unroasted sample. This may be attributed to the oxidation, hydrolysis and thermal degradation of bioactive

Table 1: Functional Properties of WSF.

Parameters	RWSF	URWSF	't' value	Significance
WAC (%)	11.3	8.66	25.0564	0.0016*
OAC (%)	27.2	21.50	66.1439	0.002*

*Significant at the 0.05 level ($p<0.05$).

Table 2: Phytochemical composition of WSF.

Parameters	RWSF	URWSF	't' value	Significance
Saponin (mg/g)	4.7	11.62	-41.3973	0.006*
Alkaloid (mg/g)	21.3	47.2	-156.4006	0.0000*
Flavonoids (mg/g)	1.8	3.51	-37.6655	0.0007*

*Significant at the 0.05 level ($p<0.05$).

Table 3: Antioxidant activity of WSF.

Parameter	RWSF	URWSF	't' value	Significance
Antioxidant activity (%)	12.4	31.2	-108.4761	0.001*

*Significant at the 0.05 level ($p<0.05$).

compounds.[22] Similar findings were observed in a study, where roasting of sesame seeds at higher temperatures reduced the phytochemical and polyphenolic components of the seed. However, the deshelling process was useful in removing the anti-nutrients present in the seed.[23]

In the present study, the amounts of alkaloids and flavonoids in dried, dehulled and unroasted WSF were found to be similar to the values reported for unroasted, deshelled watermelon seed flour in a previous study by,[24] both indicating higher concentrations of these phytochemicals in the unroasted WSF.

Overall, the phytochemicals analyzed in this study are well documented for their health-promoting effects. However, roasting led to a significant reduction in their concentrations, suggesting that excessive heat treatment may compromise the bioactive properties of watermelon seed flour.

Antioxidant activity of watermelon seed flour

The antioxidant activity evaluated using the DPPH radical scavenging assay indicated that roasting caused a significant reduction in the antioxidant activity of watermelon seed flour. This reduction is probably to the thermal degradation of heat-sensitive antioxidant compounds, such as phenolics, flavonoids, vitamin C and vitamin E which are known to contribute to radical scavenging capacity.[25]

Moreover, the high antioxidant activity of URWSF might be due to the higher levels of phytochemicals such as saponins, alkaloids and flavonoids present in it which are known to exhibit antioxidant activity. Nevertheless, the antioxidants found in the watermelon seed flour can still provide therapeutic benefits by reducing inflammation and oxidative stress.

CONCLUSION

The present study reveals that watermelon seed flour possesses significant functional properties, phytochemical contents and antioxidant activity which highlight it as a functional food ingredient. Roasting was found to enhance the water and oil absorption capacities of the flour, thereby improving its functionality in food formulations. However, roasting led to a reduction in antioxidant activity and phytochemical contents compared to unroasted flour. Among the phytochemicals analyzed, alkaloids were most abundant followed by saponins and flavonoids. Their functional properties and bioactive compounds suggest potential value in food formulation and product development. Thus, valorization of watermelon seeds in food formulations offers a sustainable approach to food processing and waste minimization.

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ABBREVIATIONS

WAC: Water absorption capacity; **OAC:** Oil absorption capacity; **DPPH:** 1,1-diphenyl-2-picrylhydrazyl; **WSF:** Watermelon seed flour; **RWSF:** Roasted watermelon seed flour; **URWSF:** Unroasted watermelon seed flour.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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AUTHOR CONTRIBUTION

Both authors contributed to the conceptualization and design of the study. Author 1 conducted the experiments, performed data analysis and also used support from an external agency. Author 1 drafted the manuscript and author 2 provided project supervision and critically reviewed as well as edited the manuscript. The final draft of the manuscript was read and approved by both authors.

DATA AVAILABILITY STATEMENT

The generated datasets which have been analysed in the present study are available from the corresponding author upon reasonable request.

SUMMARY

This study aimed to assess the effect of roasting on the functional properties, phytochemical composition and antioxidant activity of watermelon seed flour. Commercially purchased dried, deshelled watermelon seeds were roasted and powdered into fine flour. Both roasted and unroasted watermelon seed flour were analyzed for functional properties (water and oil absorption capacities), phytochemical constituents (saponins, alkaloids, and flavonoids), and antioxidant activity using standard analytical methods.

Roasting indicated that roasting significantly enhanced the water and oil absorption capacities, indicating improved functional attributes, but resulted in a marked decline in phytochemical content and antioxidant activity due to thermal degradation of heat-sensitive compounds. These findings suggest that controlled roasting can improve functionality while excessive heat may reduce nutritional and bioactive quality. The study also highlights the sustainable potential of watermelon seeds as a value-added ingredient in functional food development.

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