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UTILIZATION OF WATERMELON RIND WASTE POWDER FOR DEVELOPING BAKERY PRODUCTS

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Annatation: Watermelon rind waste powder (WRWP) is a valuable by-product obtained from watermelon processing and is known to be a rich source of dietary fiber, minerals, and bioactive compounds. Therefore, it holds great potential for use in the development of functional and value-added food products, particularly in the bakery industry. The present study was designed to evaluate the potential of WRWP as a functional ingredient in the preparation of cakes and biscuits.

Keywords: Bakery products, functional foods, physicochemical and sensorial properties, utilization of agro-waste, watermelon rind waste powder.

Introduction. In recent years, the global demand for nutritious, innovative, and sustainable food products has grown significantly due to the increasing awareness of healthy dietary habits and the need for environmentally responsible food systems (Torres and Guerra, 2022). Among various fruits, watermelon (Citrullus lanatus) is one of the most popular and widely consumed fruits worldwide, primarily valued for its sweet, juicy, and refreshing flesh. However, the rind of the watermelon, which constitutes a considerable portion of the fruit, is often overlooked and discarded as waste during processing and consumption (Nkoana et al., 2020).

Scientific studies have revealed that watermelon rind is a rich source of essential nutrients, including minerals such as calcium, iron, magnesium, zinc, and potassium, as well as vitamins A, B-complex, and C. Moreover, it contains biologically active compounds such as the amino acids citrulline, glutamine, and arginine, along with unsaturated fatty acids (Olamide et al., 2011; Zia et al., 2021). Since the rind possesses lower sugar and higher dietary fiber compared to the red fleshy part, its inclusion in the human diet helps to slow down the absorption of sugar in the digestive system, thereby contributing to better glycemic control. Interestingly, research indicates that the rind contains not only the same nutrients as the edible flesh but also higher concentrations of antioxidants, minerals, vitamins, and other bioactive compounds (Dubey et al., 2021).

It is estimated that the rind makes up nearly 30% of the total fruit weight, meaning a significant portion of the watermelon is typically discarded as waste. Therefore, utilizing watermelon rind as an ingredient in food processing could enhance the nutritional quality of food products while simultaneously reducing agro-industrial waste (Al-Sayed and Ahmed, 2013). This approach aligns well with the global agenda of promoting sustainable food production and circular economy principles.

At the same time, society is facing major dietary and nutritional challenges. The global population is projected to rise exponentially, reaching approximately 9.8 billion people by 2050 (UN, 2017). This rapid population growth will increase pressure on global food systems, making it more difficult to ensure that everyone has access to safe, nutritious, and affordable food (FAO, 2023). Consequently, utilizing fruit and vegetable by-products to develop or enhance food products represents a vital strategy to combat hunger, malnutrition, and food waste.

According to Al-Sayed and Ahmed (2013), watermelon rind waste powder contains valuable nutrients, including 11.17% protein, 2.44% fat, 13.09% ash, 56.00% carbohydrates, and 10.61% moisture content. The rind's high carbohydrate and moderate protein content make it a

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promising material for value-added food formulations. It can be dried and milled into powder form, which can then be incorporated into various bakery products or used as a functional ingredient in the food industry.

Researchers have explored diverse applications of watermelon rind powder in the preparation of jams, candies, and other confectionery products (Nadeem et al., 2022). Additionally, it has been successfully incorporated into bakery items such as cookies (Naknaen et al., 2016), bread (Badr et al., 2018), and noodles (Chakrabarty et al., 2020). Bakery products are universally consumed and form a major component of the daily diet. However, most conventional bakery products are low in essential nutrients, rich in saturated fats and sugars, and deficient in dietary fiber (Hughes et al., 2020).

Therefore, enriching bakery products with natural ingredients derived from fruit and vegetable by-products, such as watermelon rind powder, can significantly improve their nutritional value. Furthermore, it offers a cost-effective alternative to expensive raw materials, especially beneficial for non-wheat-producing regions.

In this context, the present study seeks to evaluate the potential of partial replacement of wheat flour with watermelon rind powder in the preparation of bakery items like cakes and biscuits. The study focuses on assessing the impact of this substitution on the physicochemical, nutritional, and organoleptic properties of the final products. Such innovations not only promote nutrition-sensitive food development but also contribute to sustainability and waste minimization in the food industry.

The watermelon rind, therefore, represents a promising source of dietary fiber and essential nutrients that can be effectively utilized in various functional food applications, helping to bridge the gap between food innovation, nutrition, and sustainability.

Materials and methods

Preparation of watermelon rind waste powder (wrwp)

Freshly harvested watermelon fruits were first washed thoroughly with running tap water followed by distilled water to remove any adhering dust, soil particles, and surface contaminants. The outer green peel was carefully separated using a stainless-steel knife, ensuring that only the white rind portion was collected.

The separated rinds were then weighed, sliced into thin strips, and arranged uniformly on stainless trays. Drying was carried out in a thermal dehydrator maintained at 60°C until a constant weight was achieved, corresponding to a final moisture content of 8–10%.

Once dried, the slices were ground using an electric grinder to obtain a fine powder, which was subsequently sieved through a mesh sieve to ensure uniform particle size. The powdered rind was then weighed, packed into sterilized airtight glass jars, labeled, and stored under refrigeration at 6 ± 1°C until further use in formulation and analysis.

Formulation of Optimized Recipes for Watermelon Rind Waste Powder-based Cake and Biscuit

To develop an optimized formulation for watermelon rind waste powder (WRWP)-based cakes and biscuits, several preliminary trials were conducted. In each trial, wheat flour was partially replaced with different proportions of WRWP (0%, 10%, and 20%) to determine the most acceptable level of substitution in terms of sensory and textural attributes.

A panel of trained judges evaluated all formulations for appearance, taste, texture, and overall acceptability. Based on their feedback, the 20% WRWP substitution level in both cake and biscuit formulations was found to be the most acceptable, and therefore selected as the final optimized recipe for further analysis (Khan et al., 2025).

Table 1. Treatments used in the study

Treatment Code	Product Type	WRWP Substitution (%)	Description
T1	Cake	0	Control (without WRWP)
T2	Cake	10	10% wheat flour replaced by WRWP

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Treatment Code	Product Type	WRWP Substitution (%)	Description
T3	Cake	20	20% wheat flour replaced by WRWP
T4	Biscuit	0	Control (without WRWP)
T5	Biscuit	10	10% wheat flour replaced by WRWP
T6	Biscuit	20	20% wheat flour replaced by WRWP

Treatments of Cakes and Biscuits with and without Watermelon Rind Waste Powder
Detailed formulations for each treatment (T1–T6) were prepared based on the optimized recipes. Tables 2 and 3 represent the ingredient composition of cakes and biscuits formulated with and without watermelon rind waste powder. Each formulation was prepared under identical processing conditions to ensure valid comparative evaluation.
Development of Cakes with and without Watermelon Rind Waste Powder
The preparation of cakes (T1, T2, and T3) was carried out according to the standard method of Hoque and Iqbal (2015) with slight modifications. In the test samples, wheat flour was partially replaced with WRWP at levels of 10% (T2) and 20% (T3), while T1 served as the control without WRWP.
Other ingredients were used at fixed proportions relative to the flour base:
- Butter – 82%,
- Eggs – 82%,
- Sugar – 82%,
- Baking powder – 3%,
- Salt – 1.5%,
- Wheat flour – 80% (for control).

For sample preparation, the accurately weighed ingredients were combined in the following sequence:
1. Creaming stage: Sugar and butter were mixed in a mechanical mixer for 15–20 minutes until a light, creamy texture was obtained.
2. Mixing stage: Eggs, WRWP (for T2 and T3 only), wheat flour, and remaining dry ingredients were gradually added and mixed for 10 minutes at low speed to achieve a homogeneous batter.
3. Baking stage: The prepared batter was poured into pre-greased baking pans, and baked in a preheated electric oven at 160°C for 40–45 minutes.

After baking, cakes were cooled at ambient temperature, removed from molds, and packed in polyethylene bags for subsequent physicochemical and sensory analyses.
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