



# From Waste to Value: Mandarin Peel Powder in Cookies



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## Abstract

Food waste valorization offers innovative opportunities to transform discarded by-products into valuable food ingredients. This study investigates the incorporation of mandarin peel powder into cookie formulations, assessing its impact on nutritional composition, physicochemical stability, and sensory acceptance. Results demonstrated that cookies enriched with mandarin peel powder contained higher levels of energy, proteins, fats, fiber, and vitamin C compared to control samples. Physicochemical parameters such as moisture content, water activity, acidity, and pH showed improved stabilization, supporting extended shelf life. Sensory evaluation revealed positive consumer acceptance, confirming the feasibility of integrating citrus by-products into baked goods. By converting mandarin peels from waste into functional components, this research highlights the dual benefits of enhancing dietary quality and reducing environmental burdens. This research highlights the potential of mandarin peel as a valuable resource for improving the quality of baked products, combining nutritional benefits with the reduction of food waste.

## Introduction

Mandarins (*Citrus reticulata*) are widely cultivated fruits found in tropical and subtropical regions, offering a variety of nutritional benefits. These fruits can be consumed fresh, processed into various products, or used as ingredients in functional foods, contributing to the improvement of dietary quality. The peels of mandarins, which make up over 30% of the fruit's total mass, often generate significant amounts of organic waste, much of which ends up in landfills, posing a challenge for the food processing industry in managing this waste. This situation underscores the need for innovative strategies to valorize fruit waste in line with sustainable development principles.

Citrus peels are known to contain fiber, pectin, vitamin C, polyphenols, and other bioactive compounds, giving them added nutritional value.

This study aims to explore the potential of using mandarin peel waste in cookies as a sustainable approach to address waste management challenges while enhancing the nutritional quality of the products. By incorporating mandarin peel powder into baked goods, it is possible to increase fiber content, pectin, and antioxidants, thereby improving the nutritional and functional values of cookies.

Furthermore, the peels provide unique flavors and aromas, making this approach appealing to consumers seeking tastier and healthier products.

The research evaluates the benefits of mandarin peel powder in cookies and its relationship with the enhancement of nutritional quality and sensory characteristics of the final products.

## MATERIALS & METHODS

For the preparation of biscuits, various ingredients, including wheat flour and mandarin fruits (*Citrus reticulata*), were sourced from local markets in Prishtina, Kosovo. Control samples (C) were made without mandarin peel powder (PP), using only white wheat flour. The fruits were washed with clean water to ensure cleanliness, and the peels (approximately 1 kg) were chopped, dried until the moisture content reached 5%, and then converted into powder. Different formulations were created by substituting varying amounts of wheat flour with mandarin peel powder. For example, biscuits with 5% (B-MPP-5) and 10% (B-MPP-10) were prepared. Samples without PP were compared with the formulations to evaluate the sensory and nutritional properties. Nutritional composition was assessed following methods described by the Association of Official Analytical Chemists (AOAC) in 2016. Analyses included total protein, fat, ash, total acidity, and vitamin C content, expressed as grams or milligrams per 100 grams of fresh sample weight. Energy values were calculated using Atwater factors. A panel of 12 untrained participants evaluated the samples based on appearance, taste, aroma, texture, and overall quality using a 9-point hedonic scale. Statistical analyses were conducted using IBM SPSS Statistics (Version 24.0).

Group	Control Cookies (C)	Mandarin Peel Powder Cookies (MPP)
White Wheat Flour	46.5%	46.5%
Sugar	13.5%	13.5%
Salt	0.5%	0.5%
Baking Powder	1.5%	1.5%
Olive Oil	8%	8%
Eggs	10%	10%
Yogurt	20%	20%
Mandarin Peel Powder	0%	5% (B-MPP-5) / 10% (B-MPP-10)

### Note:

- **B-MPP-5** refers to cookies containing 5% mandarin peel powder.
- **B-MPP-10** refers to cookies containing 10% mandarin peel powder.

Table 1. Recipes for Producing Cookies with Mandarin Peels

## Results

The nutritional analysis of biscuits incorporating mandarin peel powder shows notable enhancements compared to the control group (C\*), as illustrated in Table 2. The biscuits with 5% mandarin peel powder (B-MPP-5) exhibit an increase in protein content (5.40 g) and vitamin C levels (16.4 mg) compared to the control, with energy values rising to 1490 kJ. The 10% mandarin peel powder biscuits (B-MPP-10) further improve these parameters, displaying the highest protein content (5.60 g), fat (11.3 g), carbohydrates (58.2 g), and vitamin C (17.8 mg), along with an energy value of 1510 kJ. The sensory characteristics of cookies enriched with mandarin peel powder indicated that the products were visually appealing and had good flavor, aroma, and texture, with ratings ranging from 6 to 9. The samples with mandarin powder (B-MPP-5) received the highest rating for overall quality (8.25), suggesting that the inclusion of mandarin peel improves the sensory attributes of the cookies, making them more preferred by panelists.

These findings suggest that incorporating mandarin peel powder significantly enhances the nutritional profile of the biscuits, potentially providing additional health benefits. Consequently, they support the idea that fruit peel powders can improve both the quality and diversity of baked products.

Nutritional Parameter	Control (C*)	B-MPP-5	B-MPP-10
Energy (kJ)	1384	1490	1510
Protein (g)	4.85 ± 0.03	5.40 ± 0.29	5.60 ± 0.27
Fat (g)	9.9 ± 0.17	10.8 ± 0.11	11.3 ± 0.13
Carbohydrates (g)	56.1 ± 0.09	56.9 ± 0.21	58.2 ± 0.03
Ash (g)	0.69 ± 0.11	1.16 ± 0.03	1.36 ± 0.04
Vitamin C (mg)	8.83 ± 0.3	16.4 ± 0.6	17.8 ± 0.9

### Note:

- **C\***: Control cookies without mandarin peel powder
- **B-MPP-5**: Cookies with 5% mandarin peel powder
- **B-MPP-10**: Cookies with 10% mandarin peel powder

Table 2. Nutritional Composition of Biscuits with Mandarin Peel Powder

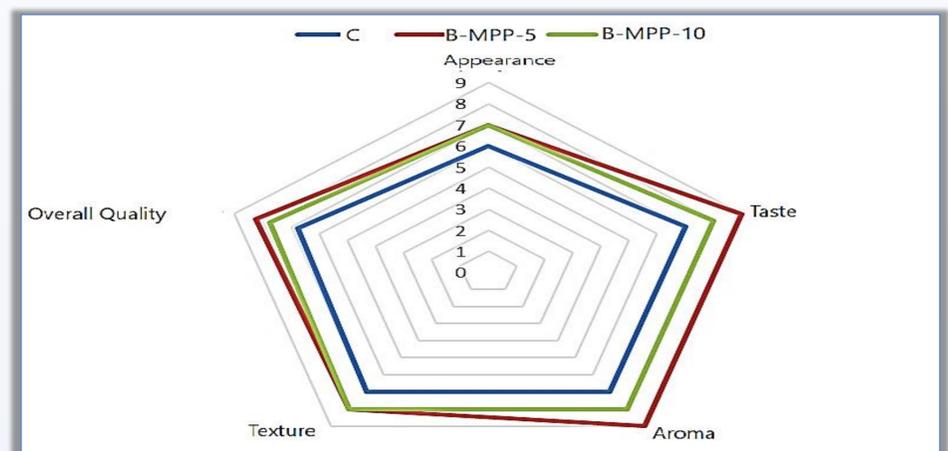


Figure 1. Sensory characteristics of biscuits

## CONCLUSIONS

The addition of mandarin peel powder significantly improves the physicochemical and sensory characteristics of cookies, increasing nutritional values such as energy, protein, and vitamin C. The powder also reduces moisture content and water activity, enhancing product stability. These results suggest that fruit peel powders have great potential for developing high-quality baked goods with nutritional benefits.

## Main references

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