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# Studies on physicochemical and sensory characteristics of nutrient-rich biscuits prepared from blends of carrot and mango peel powder

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**Abstract**
This study examines biscuits made with blends of mango peel powder (MPP) and carrot powder (CP). The chemical compositions of mango peel powder and carrot powder were analysed to understand their nutritional profiles and potential as functional ingredients. The experimental objectives were to assess physio-chemical characteristics of nutrient-rich biscuits developed using blends of wheat flour (WF), mango peel powder (MPP), and carrot powder (CP). The study aimed to enhance the nutritional and sensory qualities of traditional biscuits by incorporating wheat flour (WF), mango peel powder (MPP), and carrot powder (CP) in varying proportions. Six different formulations were prepared with varying proportions of WF, MPP, and CP: $T_1$ (80% WF, 20% MPP), $T_2$ (80% WF, 20% CP), $T_3$ (80% WF, 10% MPP, 10% CP), $T_4$ (70% WF, 30% MPP), $T_5$ (70% WF, 30% CP), and $T_6$ (70% WF, 15% MPP, 15% CP). Six formulations ($T_1$-$T_6$) were tested for their physicochemical properties and sensory attributes. Among these, the $T_3$ formulation (80% WF, 10% MPP, 10% CP) emerged as the most favorable, having balancing moisture content (5.98%), protein content (9.63%), and antioxidant activity (67.52%). $T_3$ also excelled in sensory evaluations, scoring high in color (8.0±0.6), texture (8.1±0.5), taste (8.3±0.6), mouthfeel (7.8±0.4), and overall acceptability (8.05±0.2). This balance likely results from the synergistic effects of MPP and CP.

**Keywords:** Biscuits, fortification, mango peel powder, carrot powder

## Introduction
Bakery products have been a part of human consumption for centuries, and among them, biscuits are the most widely consumed. Biscuits are a significant component of the human diet and are commonly consumed with tea. They are also used as a weaning food for infants. The ingredients used in making biscuits are relatively simple, including soft wheat flour, shortening, sugar, fat, and eggs. However, these ingredients are low in nutritional and biological value. The soft wheat flour used in biscuit production lacks several essential nutrients, such as certain vitamins, mineral elements, and dietary fiber (Fakhreddin Salehi 2019) [22].

The fruit of Mango (*Mangifera indica* L.) is consumed globally and highly valued for its appealing taste and beneficial nutritional qualities. Considering that the weight of mango peels and stones accounts for approximately 35-60% of the overall fruit weight, and taking into account the annual global production of mango, which is approximately 41.54 million tonnes, it can be estimated that around 15-25 million tonnes of peels and stones are produced each year. Disposing of mango byproducts such as peels and stones in landfills can lead to significant environmental issues such as the emission of greenhouse gases and contamination of leachate. Such actions also result in economic losses. The utilization of mango peels in the production of food items provides a fresh revenue stream for mango processing companies. It helps to decrease the amount of biowaste that is discarded. Additionally, this approach helps to alleviate the excessive consumption of natural resources necessary for producing ingredients or additives, which can be substituted by compounds present in mango peels.

Carrot, a crop with various colors, is grown annually for its edible purposes and belongs to the Apiaceae family. In temperate regions, it can be cultivated throughout the year due to favorable conditions.

Carrot is a root crop with a variety of pigments in the form of carotenoids and flavonoids that provide both color and antioxidant properties. The bioactive components in carrots are primarily concentrated on the outer side of the root (cortex), and its significant amounts of vitamins, bioactive components, and minerals have earned it a position among the top ten nutritious fruits and vegetables (Alasalvar *et al.*, 2001) [3]. Carrots are considered a vitaminized food as they are abundant sources of carotene and ascorbic acid. They also contain significant amounts of moisture, protein, fat, carbohydrates, sugars, and fiber, ranging from 84 to 95%, 0.6 to 2.0%, 0.2 to 0.7%, 9.58 to 10.6%, 5.4 to 7.5%, and 0.6 to 2.9%, respectively (Hashimoto and Nagayama, 2004).

## 2. Materials and Methods

Ripe, matured and disease-free carrot were bought from a local market in Jalandhar, Punjab. Matured and disease-free mango were bought from a local market in Jalandhar, Punjab

### 2.1 Methods

Laboratory methods and procedures used were adopted from Tobaruela *et al.*, (2018) [26]. Total soluble solids, Moisture content, titratable acidity, pH, total phenolic content, carbohydrates, ash content, crude fat, tannins, flavonoid content, antioxidant activity were estimated in the flours and the biscuits

### 2.2 Preparation of MPP

Collection of peels from fresh ripe mangoes
↓
Clean and rinse
↓
Steam blanching for 5 minutes
↓
Peels dried in tray drier (60+2 °C for 8-10 hours)
↓
Grind into flour
↓
Sieve through a 425 micron mesh metallic sieve (BSS Std. No. 36)
↓
Packaging in aluminum laminated pouches and stored at room temperature

### 2.3 Preparation of CP

Collection of carrot
↓
Clean and rinse
↓
Cutting and removal of peel (peeler)
↓
Steam blanching for 5 minutes
↓
Drying of pretreated carrot (mechanical dehydrator at 60+2 °C for 8-10 hours)
↓
Grinding of dried carrot (mechanical grinder)
↓
Sieving through BSS Std.No.36 (425 micron) mesh metallic sieve
↓
Packaging in aluminum laminated pouches

### 2.4 Treatment details

The biscuits were prepared using the creaming method based on the investigation by Molina *et al.*, (2021) [20]. Table 1 outlines the different combinations of fortification with mango peel powder, carrot powder, and wheat flour.

**Table 1:** Treatment details

| Treatments | Wheat flour | Mango peel powder (%) | Carrot powder (%) |
|---|---|---|---|
| $T_1$ | 80 | 20 | 0 |
| $T_2$ | 80 | 0 | 20 |
| $T_3$ | 80 | 10 | 10 |
| $T_4$ | 70 | 30 | 0 |
| $T_5$ | 70 | 0 | 30 |
| $T_6$ | 70 | 15 | 15 |

### 2.5 Sensory analysis

A nine-point hedonic scale was employed to analyze the sensory evaluation of the developed biscuits, assessing parameters such as color, texture, taste, aroma, and overall acceptability. The evaluation was conducted by 10 semi-trained judges

## 3. Results and Discussion

### 3.1 Physio-chemical characteristics of carrot flour and mango peel powder

Carrot powder exhibits several key properties, demonstrating its potential in food applications. It has a low moisture content of 3.9%±0.02, which ensures good stability and resistance to microbial growth, comparable to the 4.2% reported by Tiwari *et al*., 2018 [28]. The total soluble solids (TSS) content of 17.8°B±1.2 indicates a moderate concentration of dissolved solids, enhancing its flavor and nutrient profile. Rich in sugars, carrot powder contains 4.17%±0.07 reducing sugars and 8.6%±0.18 total sugars, contributing to a sweet taste profile. The pH is slightly acidic at 5.93±0.14, influencing its taste and stability, similar to Tiwari *et al*. findings. Nutritionally, it contains 3.94%±0.14 protein and 6.0%±0.10 ash, highlighting its value as a plant-based protein source and mineral contributor, again aligning with Tiwari *et al*. 2018 [28] report of 3.7% protein and 6.1% ash. The powder also contains significant amounts of total phenols (302.7g GAE/100 g±0.18) and flavonoids (24.0 mg/100 g±5.01), indicating strong antioxidant properties. The titratable acidity of 0.62%±0.19 and low tannin content (0.57 mg/100 g±0.07) suggest a mild acidic taste without significant astringency, with similar values reported by Kamel *et al*., 2023 [27].

**Table 2:** Physico- chemical characters of carrot flour and mango peel powder

| Parameters | Carrot powder | Mango peel powder |
|---|---|---|
| Moisture (%) | 3.9±0.02 | 6.78±0.04 |
| TSS (°B) | 17.8±1.2 | 10.2±0.02 |
| Reducing sugar (%) | 4.17±0.07 | 1.92±0.3 |
| Total sugar (%) | 8.6±0.18 | 2.9±0.41 |
| pH | 5.93±0.14 | 4.3±0.13 |
| Titratable acidity (%) | 0.62±0.19 | 0.22±0.31 |
| Ash (%) | 6.0±0.10 | 3.6±0.04 |
| Total phenol (mg GAE/100 g) | 302.7±0.18 | 890.6±0.27 |
| Total flavonoid (mg /100 g) | 24.0±5.01 | 0.13±0.08 |
| Tanin (mg/100 g) | 0.57±0.07 | 0.41±0.07 |
| Protein | 3.94±0.14 | 4.12±0.08 |

Mango peel powder has a moderate moisture content of 6.78%±0.04, providing shelf stability while retaining nutrients, similar to the 4.92%±0.32 reported by Ashoush *et* *al*., 2011 [5]. Its total soluble solids (TSS) content is 10.2°B±0.02, indicating a good concentration of dissolved solids. It contains modest levels of reducing sugars (1.92%±0.3) and total sugars (2.9%±0.41), offering a mildly sweet taste. The powder's pH is 4.3±0.13, comparable to values reported by Ajila *et al*., 2010. With an ash content of 3.6%±0.04, it indicates essential mineral presence, and it is rich in total phenols (890.6 mg GAE/100 g±0.27). The tannin content is low (0.41 mg/100 g±0.07), and it has a good protein level (4.12±0.08), aligning with Ashoush *et al*. 2011 [5] report of 3.88±0.59 ash and 3.6±0.15 protein content.

**Table 3:** Physio-chemical characters of developed biscuits

| | Moisture (%) | Protein | DPPH (%) | Carbohydrate | Ash | Fibre | Fat (%) |
|---|---|---|---|---|---|---|---|
| $T_1$ | 6.14±0.02$^a$ | 9.78±0.03$^a$ | 82.84±0.04$^b$ | 62.2±0.55$^c$ | 1.81±0.05$^b$ | 3.9±0.37$^b$ | 19.29±0.08$^{ab}$ |
| $T_2$ | 5.59±0.04$^c$ | 9.32±0.05$^b$ | 58.62±0.07$^f$ | 66.4±0.69$^b$ | 1.91±0.05$^{ab}$ | 3.4±0.38$^b$ | 18.82±0.10$^d$ |
| $T_3$ | 5.98±0.03$^b$ | 9.6±0.06$^a$ | 67.5±0.42$^d$ | 63.1±0.5$^c$ | 1.86±0.05$^{ab}$ | 3.45±0.39$^b$ | 18.99±0.07$^{cd}$ |
| $T_4$ | 5.89±0.04$^b$ | 9.18±0.02$^{bc}$ | 90.02±0.05$^a$ | 63.4±0.46$^c$ | 1.85±0.04$^{ab}$ | 5.01±0.09$^a$ | 19.55±0.22$^a$ |
| $T_5$ | 5.21±0.03$^e$ | 9.02±0.07$^c$ | 61.01±0.08$^e$ | 68.2±0.48$^a$ | 1.97±0.02$^a$ | 4.18±0.10$^{ab}$ | 18.84±0.04$^d$ |
| $T_6$ | 5.42±0.04$^d$ | 9.10±0.12$^c$ | 75.2±0.3$^c$ | 65.8±0.53$^b$ | 1.89±0.04$^{ab}$ | 4.94±0.41$^a$ | 19.16±0.04$^{bc}$ |

### 3.2 Effect of different types of flour on biscuit's chemical properties

The differences in the physiochemical properties of biscuits made with varying ratios of wheat flour (WF), mango peel powder (MPP), and carrot powder (CP) can be attributed to the unique compositions and interactions of these ingredients. Moisture content, crucial for shelf stability, varies significantly across treatments, with $T_1$ (80% WF, 20% MPP) showing the highest moisture at 6.14%, and $T_5$ (70% WF, 30% CP) the lowest at 5.23% due to the differing hygroscopic properties of MPP and CP. Protein content is highest in $T_1$ at 9.78% and lowest in $T_5$ at 9.02%, reflecting the protein levels in the ingredients. Antioxidant capacity, measured by DPPH activity, peaks in $T_4$ (70% WF, 30% MPP) at 90.09%, with $T_2$ (80% WF, 20% CP) the lowest at 58.62%, influenced by MPP's high antioxidant activity (Bandyopadhyay *et al*., 2014) [7]. Carbohydrate content is highest in $T_5$ at 68.22, and treatments with more MPP or CP generally have higher carbohydrate levels (Ashoush *et al*., 2011) [5]. Ash content, indicating mineral content, is highest in $T_5$ at 1.96, aligning with the mineral-rich nature of CP and MPP (Nisha *et al*., 2020; Baljeet *et al*., 2014) [21, 9]. Fiber content peaks in $T_6$ (70% WF, 15% MPP, 15% CP) at 4.9525, as MPP and CP are high in fiber (Ajila *et al*., 2008; Ukeyima *et al*., 2019). Fat content is highest in $T_4$ at 19.54%, reflecting MPP's higher fat content compared to WF and CP (Nisha *et al*., 2020; Alam *et al*., 2010) [21, 1]. These findings highlight the importance of ingredient ratios in determining the nutritional and sensory attributes of biscuits.

### 3.3 Effect of different types of flour on biscuit's antioxidant properties

When analyzing The DPPH (2,2-diphenyl-1-picrylhydrazyl) % activity, which measures the antioxidant capacity of the biscuits, varies significantly across the six treatments, reflecting the influence of different proportions of wheat flour (WF), mango peel powder (MPP), and carrot powder (CP). Treatment $T_1$ (80% WF, 20% MPP) has a mean DPPH activity of 82.83% with a standard deviation (SD) of 0.04. This high antioxidant activity is primarily due to the inclusion of MPP, which has a high DPPH activity, significantly enhancing the antioxidant capacity of the biscuits despite the majority composition being wheat flour. Treatment $T_2$ (80% WF, 20% CP) exhibits the lowest DPPH activity among all treatments, with a mean of 58.62% and an SD of 0.07. The lower antioxidant activity is due to the use of carrot powder, which, while still beneficial, does not match the high antioxidant potential of MPP. Treatment $T_3$ (80% WF, 10% MPP, 10% CP) has a mean DPPH activity of 67.52% and an SD of 0.42. The combined effect of MPP and CP results in moderate antioxidant activity, higher than $T_2$ but lower than $T_1$, reflecting the balancing influence of both ingredients. Treatment $T_4$ (70% WF, 30% MPP) shows the highest DPPH activity with a mean of 90.09% and an SD of 0.05. The increased proportion of MPP, which has the highest antioxidant activity, significantly boosts the overall DPPH activity of the biscuits. Treatment $T_5$ (70% WF, 30% CP) has a mean DPPH activity of 61.05% and an SD of 0.89. Despite the higher proportion of carrot powder, the antioxidant activity remains lower than those treatments containing MPP, but it is higher than $T_2$ due to the increased quantity of CP. Treatment $T_6$ (70% WF, 15% MPP, 15% CP) displays a mean DPPH activity of 75.25% with an SD of 0.32. The balanced addition of both MPP and CP enhances the antioxidant activity, resulting in a higher value compared to treatments with a single type of powder (either MPP or CP), but lower than treatments with higher MPP content. In summary, the variations in DPPH activity among the treatments are largely attributable to the different proportions and types of powders used. MPP, having the highest DPPH activity, significantly boosts the antioxidant potential when used in higher proportions, while CP provides a moderate increase. Wheat flour, having the least antioxidant activity, results in lower overall DPPH activity in treatments where it constitutes the majority. The combination of MPP and CP offers a balanced improvement in antioxidant capacity, but the highest benefits are seen with greater MPP content. Similar values were reported by Bandyopadhyay *et al*., 2014 [7].

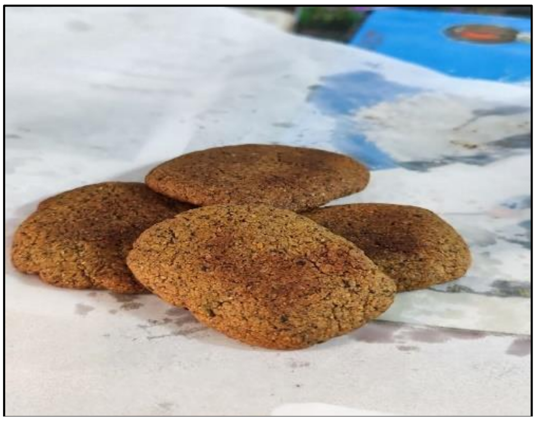

**Fig 1:** Baked biscuits

### 3.4 Sensory Evaluation

Sensory evaluation of biscuits was conducted to assess their overall quality, taste, texture, appearance, and aroma. A panel of trained evaluators participated in the analysis. The biscuits were presented to the evaluators in a randomized and blind manner to avoid bias. During, the evaluation, the appearance of the biscuits was visually examined, considering factors such as color, shape, and surface texture. The biscuits were then tasted, and the evaluators assessed their flavor, sweetness, and any specific taste attributes. Sensory evaluation of carrot flour and mango peel powder-based cookies was carried out on 9-point hedonic scale and the results are given in table 4.3. The sensory ratings of the six biscuit treatments, varying in their proportions of wheat flour (WF), mango peel powder (MPP), and carrot powder (CP), provide a comprehensive assessment of their color, texture, taste, mouthfeel, and overall acceptability. Treatment $T_3$, comprising 80% WF, 10% MPP, and 10% CP, consistently receives the highest scores across all sensory attributes. $T_3$ scores exceptionally well in color (8.0±0.6), texture (8.1±0.5), taste (8.3±0.6), mouthfeel (7.8±0.4), and overall acceptability (8.05±0.2), indicating its superior sensory profile. This treatment likely benefits from a balanced blend of MPP and CP, enhancing both flavor and texture qualities. Treatments $T_5$ (70% WF, 30% CP) and $T_6$ (70% WF, 15% MPP, 15% CP) also receive favorable ratings, particularly in taste and mouthfeel. $T_1$ (80% WF, 20% MPP) and $T_2$ (80% WF, 20% CP) demonstrate moderate sensory scores across the board, suggesting a less pronounced impact of MPP or CP at these lower proportions. $T_4$ (70% WF, 30% MPP) consistently scores lower in all attributes compared to other treatments, indicating potential challenges with texture and overall acceptability at higher MPP ratios. Overall, the sensory evaluation highlights the importance of ingredient ratios in achieving desirable sensory characteristics in biscuits, with specific combinations of MPP and CP contributing to enhanced color, texture, taste, and overall acceptability of the final product.

**Table 4:** Evaluation of fortified biscuits on the sensory characteristics / Sensory Evaluation

| Treatments | Colour | Texture | Taste | Mouthfeel | Overall Acceptability |
|---|---|---|---|---|---|
| $T_1$ | $6.3±0.9^b$ | $60±0.6^b$ | $6.1±0.8^c$ | $6±0.6^d$ | $6.1±0.7^b$ |
| $T_2$ | $6.8±0.9^c$ | $6.8±0.9^b$ | $6.8±1^b$ | $6.9±0.7^b$ | $6.82±0.2^d$ |
| $T_3$ | $8±0.6^a$ | $8.1±0.5^a$ | $8.3±0.6^a$ | $7.8±0.4^a$ | $8.05±0.2^a$ |
| $T_4$ | $5.7±0.8^d$ | $5.9±0.5^c$ | $5.8±0.4^b$ | $5.9±0.5^b$ | $5.82±0.4^b$ |
| $T_5$ | $5.7±1^c$ | $5.9±0.6^c$ | $7±0.9^d$ | $6.9±0.7^d$ | $6.9±0.6^d$ |
| $T_6$ | $5.7±0.6^a$ | $5.9±0.7^b$ | $8±0.6^a$ | $8.2±0.6^a$ | $8.07±0.5^a$ |

## 4 Conclusion

This study highlights mango peel powder and carrot powder as beneficial ingredients in biscuits. Among the six biscuit treatments evaluated, treatment $T_3$ (80% WF, 10% MPP, 10% CP) stands out as the most favorable due to its balanced physiochemical properties and exceptional sensory attributes. $T_3$ maintains an optimal moisture level (5.98%), ensuring good texture and shelf stability, and achieves a desirable protein content (9.63%) that enhances nutritional value without compromising texture. It also shows respectable antioxidant activity (DPPH activity of 67.52%), reflecting the synergistic effects of MPP and CP. Additionally, $T_3$ excels in sensory evaluations, scoring high in color (8.0), texture (8.1), taste (8.3), mouthfeel (7.8), and overall acceptability (8.05). The balanced use of MPP and CP in $T_3$ enhances flavor and overall sensory appeal, making it the preferred option among the studied formulations. This highlights the importance of ingredient selection and ratio optimization in creating a well-rounded and consumer-acceptable product.

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