

QUALITY EVALUATION OF BISCUIT INCORPORATED WITH MANDARIN PEEL POWDER

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Abstract: The current research is aimed to utilize mandarin peel in biscuits baking. Chemical composition showed that peel had high contents of ash, crude fiber; whereas low protein and carbohydrate content compared to wheat flour. Mandarin peel powder (MPP) was used in production of semi-sweet hard dough biscuits by replacing wheat flour by 3, 6 and 9 % to ensure the quality and acceptability of the biscuit. Baking increased the thickness of biscuit, whereas width and spread ratio of biscuits decreased with increasing levels of MPP. Biscuits were subjected for sensory evaluation. Biscuits formulated with 6 % MPP were comparable to control biscuits. The content of fiber, ash, ascorbic acid, carotenoids, polyphenol and antioxidant activity was found to be 0.85 %, 1.32 %, 1.5 mg / 100 g, 69 $\mu\text{g}\cdot\text{g}^{-1}$, 2150 μg gallic acid equivalents (GAE) / g and 24.5 % respectively which were significantly higher than that of control biscuit.

Keywords: *antioxidant-activity, biscuit, carotenoids, mandarin peel powder, polyphenol, spread ratio*

INTRODUCTION

Biscuits are popular baking products, consumed by a wide range of populations, due to their ready to eat nature, varied taste, long shelf life and relatively affordable cost. High competitions in the market and increased demand for healthy, natural and functional products lead to modify their nutritive composition by improvement. The higher level of wholegrain raw materials and fruits and vegetables other than wheat or other types of dietary fiber in basic recipes has increased. The attempt was to increase biscuit's protein content and quality, mineral content and bio-availability with enrich bioactive components [1 – 4].

In mandarin juice processing, 29 % of primary waste are peels [5]. So far, in Nepal, mandarin peel is not utilized in the juice processing industries or at home scale till now. The interest in mandarin peel is due to its pharmacological activity such as radical scavengers and to its higher amount of nutritional value and bioactive compounds as compared to pulp [6, 7]. In general, mandarin peel contains 22.45 % total solids, 12.5 °Bx total soluble solids (TSS), 1.38 % titratable acidity, 41.57 mg / 100 g ascorbic acid, 6.23 % total sugars, 5.99 % reducing sugars, 13.65 mg / 100 g carotenoids, 7.43 mg/100 g β -carotene, 1.85 % pectin [5]. In citrus fruits, about three-fourth of the vitamin C is present in the peel, pulp and seed, that goes waste [8]. Mandarin peel also contains naringin - a flavones-7-glycoside between the flavones ($0.420 \text{ mg}\cdot\text{g}^{-1}$, approx) and limonin ($4.69 \text{ mg}\cdot\text{g}^{-1}$ approx) [9].

Vitamin activity of carotenoids and control of mineral balance are the health benefits provided by mandarin peel [10, 11]. Mandarin peel powder was a natural source of antioxidants, flavoring agents, fiber and minerals in biscuits [12]. The health benefits of citrus fruit have mainly been attributed to the presence of bioactive compounds, such as phenolics (e.g. flavanone glycosides, hydroxycinnamic acids), vitamin C and carotenoids and possess health related properties like anticancer, antiviral and anti-inflammatory activities, etc. [13]. These clearly show that a major portion of the fruit is going waste during processing, which can be utilized for many value added products and can be valuable resources for human nutrition. Furthermore, the utilization of by-product could lead the industries to a lower waste agribusiness, increasing industrial profitability. Therefore, utilization of mandarin peel can yield both economic and environmental benefits [14].

Although mandarin peel powder is bitter in taste [14], they are better source of fiber than cereal bran and contains large amount of total polyphenol content as well as bioactive compounds. Therefore, optimized formulation prepared by incorporating mandarin peel powder can be used for biscuits making to improve the nutritional quality without affecting the sensory property. Hence, the current objective of this research was to optimize the quantity of mandarin peel powder containing fiber, ash, ascorbic acid, carotenoids, polyphenols and to fortify biscuits with above bioactive components which ensure the availability of above health enhancing bio-products through peel powder.

MATERIALS AND METHODS

Materials

Wheat flour (*Maida*), pulverized sugar, common salt, sodium and ammonium bicarbonate, glucose syrup and matured mandarin were collected from *Bhotahity* market in Kathmandu, Nepal. Malaysian red palm oil, lecithin was provided by NEBICO Private Limited Company, Balaju, Kathmandu, Nepal. *Rahul* Skimmed milk powder (SMP) of Chitwan Milk Private Limited (Chitwan, Nepal) was used. The whole peel (flavedo and albedo) was washed with clean water and peel was removed by hand peeling. Small pieces of cut mandarin peel were dried in a cabinet drier (Sunson SF9225 AT, Nepal) at 50 °C till moisture content reduce below 10 %, powdered using an electric blender and sieved through 40 mesh size screen (Ammet IS:4520, India) as described by Ojha [14].

Calculation of ingredients amounts

For mandarin peel biscuit, the amounts of ingredients were calculated according to recipe provided by NEBICO biscuit Pvt. Ltd and flour was replaced by 3 %, 6 %, 9 % mandarin peel powder as shown in Table 1.

Table 1. Recipe formulation for mandarin peel flour biscuit

Ingredients	A [g]	B [g]	C [g]	D [g]
Wheat flour (65 %)	130	126.1	122.2	118.3
Mandarin peel flour	0	3.9	7.8	11.7
Fat	24	24	24	24
Pulverized sugar	32	32	32	32
SMP (Skim Milk Powder)	1.4	1.4	1.4	1.4
Salt	1.34	1.34	1.34	1.34
Sodium bicarbonate	0.8	0.8	0.8	0.8
Ammonium bicarbonate	2	2	2	2
Lecithin	0.26	0.26	0.26	0.26
Glucose Syrup	2	2	2	2
Water	50	50	50	50

Biscuit preparation

Raw materials were weighed as given in Table 1. Shortening, pulverized sugar, syrups, milk powder, part of water, lecithin and salt was mixed to make a creamy mass. The mixing was done in mixing machine at top speed for 3 - 5 minutes as described by Smith [1]. To the creamy mass, remaining mandarin peel flour, wheat flour and chemical leaveners dissolved in water were added. The remaining water was added and the mixing continued on two-speed mixer on low speed for 10 minutes. The adhering nature of the dough in the dye indicate adequacy of mixing. The prepared dough was left for 15 minutes for lying, in order to achieve maturity for easy machinability and good surface gloss as described by Smith [1]. The matured dough was fed in the embossing dye or molders directly and then dough then conveyed to continuous baking

oven for baking (5 minutes) with the last damper open. The baking temperature profile is shown in Table 2.

Table 2. Baking temperature profile of the oven

Zone No.	1	2	3	4	5
Top Heat [°C]	230	240	240	250	200
Bottom Heat [°C]	230	250	250	210	200
Damper Position	Half-open	Half-open	Closed	Closed	Closed

Baked biscuits were cooled for 20 minutes and then packed in polypropylene bags and stored in a cool and dry place for further analysis. Biscuit was prepared in NEBICO biscuit Pvt. Ltd.

Optimization of formulation

Product was formulated by variation made on percent of flour and mandarin peel powder. Best product was chosen on basis of sensory evaluation.

Chemical analysis

Proximate compositions, carotenoid content, vitamin C content were determined according to the method of Ranganna [15]. Total polyphenol was determined by using Folin-Ciocalteu method [16]. Free radical scavenging activity (% RSS) was measured using stable radical DPPH (1,1-diphenyl 2-picrylhydrazyl) according to the method described by Chen *et al.* [17] with some modifications. 175 µL of various concentrations of extracts were added to 25 µL of 0.2 mM methanol solution of DPPH. The mixture was shaken and left for 30 min at room temperature in the dark and the absorbance was measured with a UV-Vis spectrophotometer (GENESYSTM 10S, Thermo ScientificTM, Germany) at 517 nm. All determinations were performed in triplicate. The antioxidant activity was calculated as the percent inhibition caused by the hydrogen donor activity of each sample according to the following equation (1):

$$\text{Scavenging activity (\%)} = 1 - \frac{\text{absorbance of the sample}}{\text{absorbance of the blank}} \times 100 \quad (1)$$

Total carotenoid content of mandarin peel, wheat flour and biscuit was determined according to Rainha *et al.* [18]. Methanolic extracts of mandarin peel, wheat flour and biscuit were analyzed in a UV-Vis- spectrophotometer at 470, 653 and 666 nm. The concentrations of carotenoids and chlorophylls α and β were determined according to the equations (2), (3) and (4) as follows:

$$\text{Total carotenoids } \left(\frac{\text{mg}}{\text{L}}\right) = 1000\text{Abs}_{470} - 2.860\text{Ca} - \frac{129.2\text{Cb}}{245} \quad (2)$$

$$\text{Chlorophyll } \alpha \left(\frac{\text{mg}}{\text{L}}\right), \text{Ca} = 15.65\text{Abs}_{666} - 7.340\text{Abs}_{653} \quad (3)$$

$$\text{Chlorophyll } \beta \left(\frac{\text{mg}}{\text{L}}\right), \text{Cb} = 27.05\text{Abs}_{653} - 11.21\text{Abs}_{666} \quad (4)$$

Evaluation of physical characteristics of biscuits

Diameter of biscuits was measured by laying six biscuits edge-to-edge with the help of a measuring scale. The same set of biscuits was rotated 90° and the diameter was measured. Average value of these biscuits are reported in mm. Thickness of biscuits was measured by stacking six biscuits on top of one another and taking average of six biscuits in mm. The spread ratio was calculated according to Manohar and Rao [19] using following equation (5).

$$\text{Spread ratio} = \frac{\text{Diameter (W)}}{\text{Thickness (T)}} \quad (5)$$

Sensory evaluation

Sensory evaluation was performed by 15 panelists from NEBICO Biscuit Pvt. Ltd., Kathmandu by using 9 point hedonic scoring test (9 = like extremely, 1 = dislike extremely) for color, flavor, texture and overall acceptance as described by Ranganna [15].

Data analysis

All the data obtained in this experiment were analyzed by statistical program known as Genstat release 12, Discovery edition [20], developed by VSN International Ltd. Sample means were compared by LSD method (Least Significant Difference) at 5 % level of significance and by student t-test by using Microsoft Office Excel 2007.

RESULTS AND DISCUSSION

Yield of peel powder

The data regarding the percentage peel portion on the basis of mandarin and yield of mandarin peel powder on the basis of mandarin peel were 31.33 % and 22.97 % respectively and are shown in Table 3.

Table 3. Yield percentage of mandarin peel and mandarin peel powder

Parameters	Amount [kg]	Yield [%]	Moisture content [%] (w.b.) [*]
Mandarin	15	-	-
Mandarin peel	4.7	31.33	78.87 ± 0.32
Mandarin peel powder	1.08	22.97	8.06 ± 0.36

^{*}Data after ± indicate standard deviation
w.b. – wet basis

Moisture content of fresh peel was 78.87 %, and was reduced up to 8.06 % by drying. The peel percentage of sweet orange, lemon and mandarin were 25.0, 40.0 and 28.0 %, respectively [21]. Hakim and Harris [22] revealed that mandarin, orange, grape fruit and lemon had the peel in the range from 25.0 to 45.0 %. Ahmad *et al.* [23] also revealed that % peel yield of *kinnow*, *fewtrell's early*, *malta*, *mousami* and grapefruit were in the range of 30 to 45 %. Manthey and Grohman [24] also revealed similar result for peel

percentage. Ojha *et al.* [14] also revealed that peel yield was 30.14 %. The variation in result in different literature could be due to variation in climate and soil condition [25].

Chemical composition of wheat flour and mandarin peel powder

The chemical composition of mandarin peel powder and wheat flour was given in Table 4. Mandarin peel has high ash, crude fat and crude fiber contents respectively. Compared to wheat flour, on the other hand, the peels had low protein and carbohydrate contents. Ascorbic acid was 29.8 mg / 100 g in mandarin peel whereas not detected in wheat flour. Phenolic content of wheat flour and mandarin peel powder extract were found to be 1.316 mg GAE / g and 128.95 mg GAE / g, respectively. Similarly, carotenoids content of wheat flour and mandarin peel were found to be 320 $\mu\text{g}\cdot\text{g}^{-1}$ and 2497 $\mu\text{g}\cdot\text{g}^{-1}$. Mandarin peel extract had a higher amount of antioxidant activity (73 %) as compared to wheat flour (23.72 %).

Al-Juhaimi [26] reported ascorbic acid content, phenolic content and antioxidant activity (% RSS) of mandarin peel to be 54.87 mg / 100 g, 169.54 mg GAE / 100 g and 68.57 % respectively. Ojha *et al.* [14] reported that ascorbic acid, carotenoids, phenolic content and antioxidant activity (% RSS) of mandarin peel powder to be 28 mg / 100 g, 2143 $\mu\text{g}\cdot\text{g}^{-1}$, 125.85 mg GAE / g and 72 % respectively. Total carotenoids content in the peels of *Citrus reticulata* Blanco was reported to be 2.04 ± 0.036 mg / g d.b. (dry basis) [11]. The carotenoids found in wheat are mainly xanthophylls, such as lutein and its esters, and the total carotenoid content ranges from 280 to 530 μg / 100 g depending on the variety [27]. Ueda *et al.* [28] reported that the polyphenol content in ripe peel was higher compared to that of raw peel and Mandarin peel had the higher total phenol content as compared to orange peels [29]. The total polyphenol content of citrus peel was 4.3 – 7.6 g GAE / 100 g [30]. Ghasemi *et al.* [31], reported that the total phenolic contents of *Citrus reticulata* varieties peels with the range of 104.2 – 223.2 mg GAE / g. DPPH scavenging activity of Baladi orange and Novel orange whole peel extract had ranged from 65 to 70 % and oil free peel extract had DPPH scavenging activity ranged from 65 to 77 % [32]. Phenolic content and antioxidant activity of refined flour was reported to be 1.16 – 1.55 mg ferrulic acid equivalent (FAE) / g and 4.59 – 5 μmol trolox equivalent / g [33]. Antioxidant activity of wheat flour was within the range as reported by Pathirana and Shahidi [34]. Tamayo *et al.* [35] reported that the fruits by-product had low in digestible carbohydrates, high in fiber and ash content and low calories content.

Finally, from the obtained results it could be concluded that the use of mandarin peels in bakery products may increase fiber and ash content with increased bioactive compound. Mandarin peel showed the highest antiradical efficiency and carotenoid content.

Table 4. Chemical composition of wheat and mandarin peel flour*

Parameters	Wheat flour	Mandarin peel powder
Moisture [%]	11.18 ± 0.32	8.06 ± 0.36
Crude protein [%] (d.b.)	10.81 ± 0.54	4.39 ± 0.67
Crude fiber [%] (d.b.)	0.48 ± 0.05	7.28 ± 1.02
Crude fat [%] (d.b.)	1.04 ± 0.9	4.32 ± 1.84
Total ash [%] (d.b.)	0.53 ± 0.06	4.13 ± 0.12
Carbohydrate [%] (d.b.)	87.14 ± 2.3	79.88 ± 1.64
Ascorbic acid [mg / 100 g]	ND	29.8 ± 0.9
Carotenoids [µg·g ⁻¹]	320 ± 12.1	2497 ± 18.3
Polyphenol content [mg GAE / g]	1.316 ± 2.6	128.95 ± 3.9
Antioxidant activity [% RSS]	23.72	73

*The values in the table are the mean of triplicates with standard deviation (±)
d.b. – dry basis

Biscuit physical analysis

Physical characteristics of biscuits such as diameter, thickness and spread ratio are presented in Table 5.

Table 5. Physical analysis of biscuits*

Sample	Diameter [mm]	Thickness [mm]	Spread ratio [W/T]
A	48.3 ± 0.2 ^a	6.4 ± 0.11 ^a	7.54 ^a
B	47.3 ± 0.7 ^b	6.47 ± 0.12 ^{ab}	7.31 ^{ab}
C	46.1 ± 0.9 ^c	6.52 ± 0.13 ^{bc}	7.07 ^{bc}
D	43.8 ± 0.2 ^d	6.59 ± 0.10 ^c	6.58 ^c

*The values in the table are the mean of seven samples with standard deviation (±)
Values in the row bearing different alphabet in superscript are significantly different

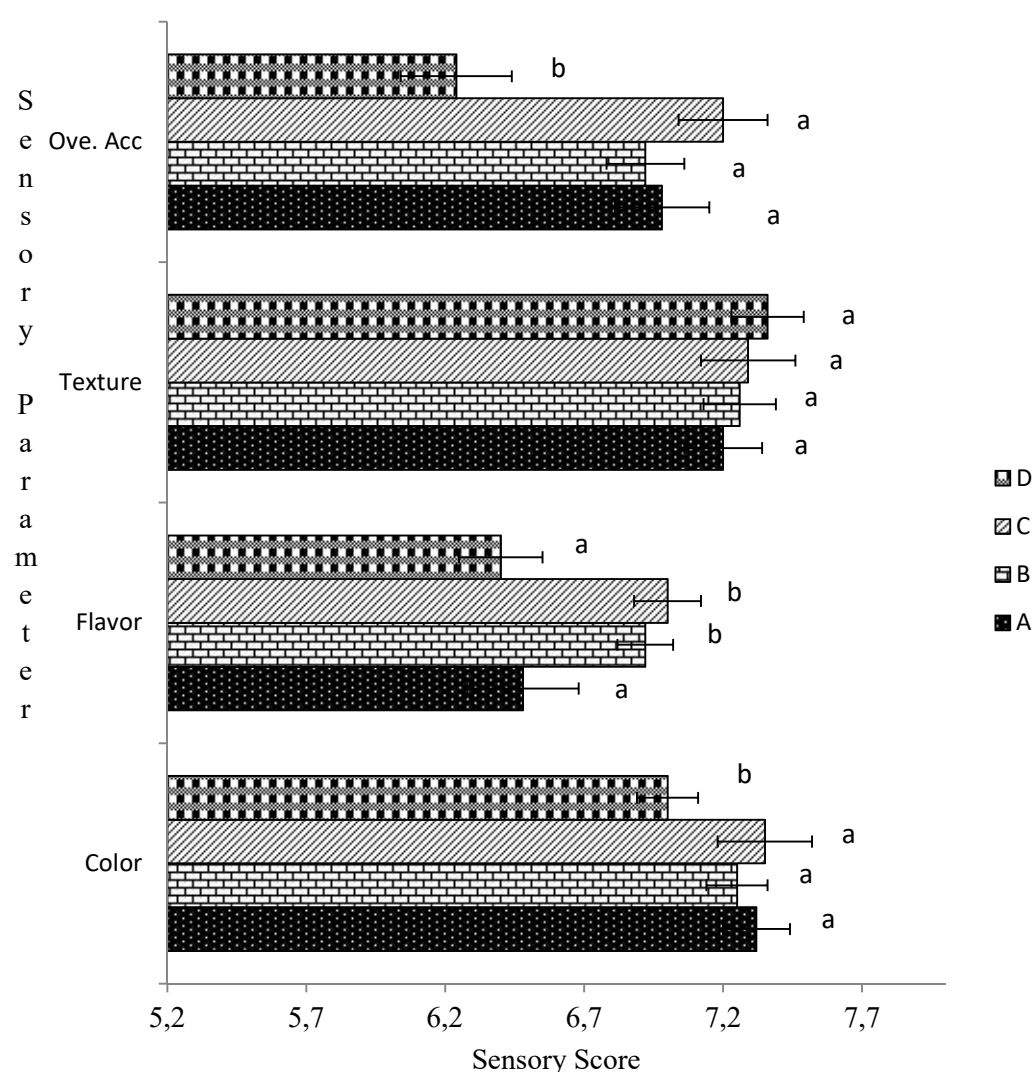
Increased mandarin peel powder percentage in wheat flour decreased the diameter and spread ratio whereas increase the thickness of biscuit. Physical characteristics of biscuits such as diameter, thickness and spread ratio were affected significantly with increasing levels of mandarin peel flour. Nassar *et al.* [7] also reported that increase in orange peel fraction decrease the spread ratio of biscuit. However, Youssef and Mousa [36] reported decreased spread ratio of biscuit with 10 % addition of different citrus peel powder. Protein quality difference and their water absorption characteristics may alter the water absorption capacity of flour and may alter the spread ratio [37]. On the other hand, strong water binding characteristics of fiber may also affect the spread ratio of biscuit [17, 38].

Sensory analysis

Sensory evaluations of biscuits were carried out to find the best ratio of MPP and wheat flour for biscuit making through sensory evaluation. The results obtained by sensory evaluation are given in the Figure 1.

The result shows that color of 6 % mandarin peel powder incorporated biscuit was comparable to control biscuit, whereas increase in mandarin peel powder further reduced the sensory score. Flavor was found to be highest for 6 % mandarin peels powder incorporated biscuit whereas lowest for control and 9 % mandarin peel powder

incorporated biscuit. There was no significant change in texture with increased percentage of mandarin peel powder. Biscuit made from 6 % mandarin peel powder incorporation was comparable to control in-terms of overall acceptability whereas 9 % incorporated biscuit get lower score. The lowest score of 9 % mandarin peel powder incorporated biscuit could be due to the more yellowish color resulting from the natural pigment present in peels [29]. Flavor was better in 3 % and 6 % mandarin peel powder incorporated biscuit compared to control biscuit, it could be due to flavoring compound present in mandarin peel [39]. However, 9 % mandarin peel powder incorporation impart a slight bitter taste might be due to higher content of polyphenols and d-limonene [14, 40]. The increase in sensory value with increase in percentage of mandarin peel powder might be due to decrease in percentage of protein with increase in proportion of MPP, which results in higher dough hydration and high consistency of dough [41].



Vertical error bars represents \pm standard deviation of scores given by 15 panellists
 Same alphabet at the top of the bars indicated not significantly different

Figure 1. Comparative study of different sample of biscuits on the basis of their sensory evaluation

Chemical analysis of control biscuit and 6 % mandarin peel powder incorporated biscuit

Incorporation of 6 % mandarin peel powder significantly increased the crude fiber, total ash, ascorbic acid, carotenoids, polyphenol content, and antioxidant activity whereas decrease the protein content and carbohydrate. There was no significant change in fat content. Carotenoid content was 4 times higher in biscuit enriched with 6 % MPP. The result is shown in Table 6.

Table 6. Chemical composition of control biscuit and 6 % mandarin peel powder incorporated biscuit*

Parameter	Control biscuit	6 % peel biscuit
Moisture [%]	2.35 ± 0.01	2.4 ± 0.03
Crude protein [%] (db)	9.07 ± 0.11	8.90 ± 0.14
Crude fiber ^S [%] (db)	0.31 ± 0.06	0.85 ± 0.09
Crude fat [%] (db)	11.11 ± 0.05	11.37 ± 0.55
Total ash ^S [%] (db)	0.81 ± 0.11	1.32 ± 0.06
Carbohydrate ^S [%] (db)	78.7 ± 0.4	77.56 ± 0.9
Ascorbic acid [mg / 100 g]	ND	1.5
Carotenoids ^S [µg·g ⁻¹]	18 ± 0.04	69 ± 0.06
Polyphenol content ^S [µg GAE / g]	720 ± 0.32	2150 ± 0.81
Antioxidant activity ^S [% RSS]	13.29	24.5

*The values in the table are the mean of seven samples with standard deviation (±).

^SIndicates significantly different at 5 % level as confirmed by *t*-test.

d.b. – dry basis

Nassar *et al.* [7] also revealed increase in fiber and ash content and decrease in protein with increase in mandarin peel percentage in biscuit. Youssef and Mousa [36] also reported increase in ash content and fiber content in biscuit with addition of different citrus peel powder. Romero-Romero-Lopez *et al.* [42] also reported increase in fiber and ash in muffin when prepared with citrus peel. Increase in these compositions may be due to higher percentage of fiber and ash in mandarin peel powder. Mandarin peel incorporated biscuit were low in protein and carbohydrate contents as compared to control biscuits due to low protein and carbohydrate content in the peel powder.

The result shows that bioactive components and antioxidant property reduced due to baking. The loss of Vitamin C in potato due to baking was up to 28 % [43]. Chen *et al.* [17], blanching, boiling, and stir-frying a few vegetables resulted in 89 to 95 %, 80 to 96 %, and 58 to 82 % retention of carotene, respectively. According to Bilgili *et al.* [38], total carotenoids degradation from flour to final product was of 24 % in bread crumb and 55 % in bread crust for bread wheat. 71.3 % of β -carotene was retained in freshly baked cookies [44]. Phenolic compounds and vitamin C are responsible for its powerful antioxidant capacity [45]. The increase in the free radical scavenging may be attributed to the increase in the contents of polyphenols and ascorbic acid through the incorporation of MPP.

CONCLUSIONS

Biscuit prepared with 6 % mandarin peel powder was comparable to control biscuit made from wheat flour based on sensory evaluation with increased bioactive component and antioxidant property. The result shows that there is an ample opportunity for use of mandarin peel in various other food products also.

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