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# Phytochemicals, antioxidant activity and quality properties of fibre enriched cookies incorporated with orange peel powder

[1]Al-Saab, A.H. and [1,2,*]Gadallah, M.G.E.

[1]*Food Science and Human Nutrition Department, College of Agriculture and Veterinary Medicine, Qassim University, Buraidah, Saudi Arabia*
[2]*Food Science Department, Faculty of Agriculture, Ain Shams University, Cairo, Egypt*

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**Abstract**

Orange peels are a rich source of dietary fibre, phenolic compounds and have effective antioxidant activity. Therefore, they can be used as a natural source in fortifying bakery products. The aim of the study was to evaluate the effect of substituting wheat flour at 5, 10, 15 and 20% with orange peel powder on the physicochemical, antioxidants and organoleptic properties of cookies. Results indicated that the orange peel powder was significantly higher in ash and crude fibres which were 4.13 and 13.20%, compared to wheat flour being 1.37 and 0.50%, respectively. It is a good source of total phenolic compounds (13.94 mg GAE/g) and it had high antioxidant activity (84.33%). Minerals and crude fibre in cookies samples were gradually increased in the levels of orange peel powder up to 20% compared to control. The highest values of phenolic contents 9.12, 8.31 and 6.10 mg GAE/g resulted in cookies that had 10, 15 and 20% of orange peel powder incorporated into it, respectively as compared to control (1.15 mg GAE/g). Cookies with all ratios of orange peel powder displayed good ability in radical scavenging activity ranged from 4.55% to 40.92%, while it was 2.65% in the control. Redness (a) and yellowness (b) of cookies were significantly high with the addition of orange peel powder in all the levels studied when compared to control, these results may be due to a slight yellow colour of orange peel powder from its carotenoid pigments in the albedo layer. The results showed no significant difference in cookies appearance and taste, up until a substitution level of 10% compared to the control, and an acceptance of the cookies sample containing 15% of orange peel powder was observed. It could be concluded that incorporation up to 15% of orange peel powder in cookies manufacturing improved the physicochemical, nutritional quality with respect to sensorial characteristics of cookies.

## 1. Introduction

Food processing industries produce very large quantities of waste, which are difficult to dispose of safely. In citrus juice processing, peels remain as primary waste and give rise to environ-mental pollution (Liu *et al*., 2006). Therefore, new by-products applications should be studied to have a positive environmental effect and to turn them into value-added products.

The waste of industrial citrus worldwide was estimated to be more than 15.1 tons, as the level of wastes obtained from the fruit's accounts for 50% of the original whole fruit weight. They consist of peels (albedo and flavedo), which are almost one-fourth of the whole fruit mass without seeds and fruit pomace, which are the remnants of its juice extraction. While fibre content in citrus is almost 25-70% (Gelroth and Ranhotra, 2001).

Citrus peel is a rich source of fibre and antioxidants, but the higher levels of astringent compounds make it unsuitable for human consumption. One important source of citrus dietary fibre is the residue from the orange juice industry (Lundberg, 2005). Fibre from the citrus can be bound with high levels of water (up to 12 times its weight) in baked goods. The func-tional properties of orange peel components such as pectin, flavonoids, carotenoids, limonene and polymethoxy flavones should be considered (Li *et al*., 2007). Citrus peel compo-nents were found to provide many health benefits, such as the effects of pectin on glycemic control, cholesterol level, cancer prevention and mineral balance control, also the effect of limonene on cancer pre-vention, and the vitamin activity of carotenoids (Xu *et*

*Corresponding author.
Email: *gadnor@yahoo.com*

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*al*., 2008; Wang *et al*., 2008).

The use of synthetic antioxidants has been applied for several foods but has had its restrictions as a result of its side effects (Caleja *et al*., 2017). A new trend in food processing is the use of natural antioxidants from plant source or wastes of food processing to be good alternatives of synthetics antioxidants, in addition to their added values as providing bioactivity in biscuits to introduce a new functional food (Bandyopadhyay *et al*., 2014).

The baking industry is considered to be one of the major parts of food processing in the world. Baked products have consumer preference because of their ready-to-eat, availability and reasonably long shelf life. Cookies are different from other baked goods like bread and cakes because of their low moisture content which ensures less microbial spoilage to provide a longer shelf life, making large scale production and distribution possible (Zaker *et al*., 2016). The objective of the present study was to investigate the impact of orange peel powder as a good source of dietary fibre and antioxidants on chemical composition, physical properties, colour attributes, sensory evaluation, and antioxidant activity of prepared cookies.

## 2. Materials and methods

### *2.1 Materials*

Soft wheat flour (70% extraction), shortening, salt, sugar and skimmed milk powder were purchased from the local market, Qassim, Saudi Arabia. Food grade dextrose, sodium bicarbonate and ammonium bicarbonate were used in cookies making. Sodium carbonate, methanol, 1,1-diphenyl-2-picrylhydrazyl radical (DPPH) and Folin-Ciocalteus phenol reagent were purchased from Sigma–Aldrich Inc. (St Louis, MO, USA).

### *2.2 Preparation of orange peel powder*

Orange peel powder (OPP) was prepared according to Zaker *et al*. (2016), peeling and further washing with tap water and scalding in a water bath at 65-70°C to remove pathogenic vegetative microorganisms was carried out. Drying of orange peel was carried out in an air oven at 50°C for 24 hrs. A grinder mill and sieves were used to obtain a powder having a particle size of less than 0.2 mm. The orange peel powder was stored in a closed bottle at 4°C until analysis and used.

### *2.3 Preparation of cookies samples*

Cookies (control sample) were prepared by using the method given by Shaikh *et al.* (2016). The dry ingredients were 100 g of wheat flour, 1.5 g of baking powder, and were mixed with the help of a commercial sigma blender for 8 min with medium speed. A homogenous paste of 26 g of fat and 35 g of sugar was prepared in a stainless steel pan. The dry mix and homogenous paste of sugar and fat were mixed thoroughly at high speed in a commercial sigma blender to obtain a uniformly mixed dough. The prepared dough was rolled in a uniform shape of 6 mm thickness and cut into round shape cookies with the help of a cutter. Cookies were baked at 175$^{o}$C for 15 min. Differently prepared cookie samples were carried out using wheat flour samples replaced separately with 0, 5, 15 and 20% of prepared orange powder.

### *2.4 Proximate composition*

Wheat flour, orange peel powder and prepared cookie samples were analyzed for their contents of moisture, ash, crude protein, lipids and crude fibre according to the methods described in AOAC (2007). The moisture content was determined by oven drying methods. Nitrogen content was estimated by the micro-Kjeldahl method and converted to protein by multiplying with the factor 5.70 for wheat flour and 6.25 for orange peel powder and cookies samples. Carbohydrates (NFE) were calculated by difference.

### *2.5 Determination of phenolic content and antioxidant activity*

The extractions of phenolic compounds from orange peel powder and cookies samples were produced as described by Bloor (2001). Half gram from each sample was extracted with 20 ml of methanol: water (60:40 v/v). The mixture was centrifuged and the supernatant was adjusted to 25 ml. An aliquot of their extracts was used for the quantification of total phenolic and antioxidant activity. Total phenolic content was measured by the Folin–Ciocalteu assay along with a spectrometer at 765 nm as described by Singleton *et al.* (1999). Gallic acid was applied as a standard, and the results were expressed as mg gallic acid equivalent (GAE) per gram.

The ability of different extracts of orange peel powder and cookie samples to scavenge DPPH free radicals was determined by the method described by Blois (1958). The scavenging effect was calculated from the reduction of absorbance at 517 nm against control (DPPH radical solution in methanol) using the following equation:

Scavenging activity (%) = $[(Abs_{control} - Abs_{sample})/ Abs_{control}] \times 100$

 

*2.6 Physical measurements*

The diameter, mm (W) of cookies was measured by laying six pieces edge-to-edge with the help of a scale and average values were reported. The thickness, mm (T) of cookies was measured by stacking six pieces on top of one another and taking the average in millimetre. The spread ratio was calculated by dividing (W) by (T) as determined by (Srivastava *et al*., 2010).

*2.7 Colour measurements*

The colour of cookies and orange peel powder was determined according to the tristimulus colour system described by Francis (1983) Hunter Lab Colour QUEST II Minolta CR-400 (Japan) by measuring the L (100 = white; 0 = black), a (+, red; -, green) and b (+, yellow; -, blue) values.

*2.8 Sensory evaluation*

Cookies fortified with OPP were submitted to sensory evaluation by a member trained academic staff of food science and human nutrition agriculture and veterinary medicine college, Qassim University. The panellists were asked to rate each sensory attribute using the control sample as the basis for evaluation. Cookies were evaluated for appearance, colour, texture, aroma, taste and overall acceptability on a 9-point hedonic scale with corresponding descriptive terms ranging from 9 'like extremely' to 1 'dislike extremely' (Hooda and Jood, 2005).

*2.9 Statistical analysis*

Statistical analysis was conducted with the SAS program (SAS, 1996). Data were represented as means ± standard errors. Statistical analysis was performed using one-way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test with P≤0.05 being considered statistically significant (Snedecor and Cochran, 1980).

## 3. Results and discussion

*3.1 Physicochemical of wheat flour and orange peel powder*

Soft wheat flour used in cookie preparation and orange peel powder were analyzed for proximate chemical composition and the data are found in Table 1. The data indicated that the orange peel powder was significantly (P≤0.05) higher in ash, lipids and crude fibres which given 4.13, 2.65 and 13.20%, respectively compared to wheat flour. On the other hand, orange peel powder was less than wheat flour in each crude protein and carbohydrate. Accordingly, it can be said that orange peel powder is a vegetable source rich in minerals and dietary fibre, which have many health benefits and can be applied as a cheap source in fortifying and enhance the nutritional quality of cookies. These results are comparable with findings reported by Humaira *et al.* (2013) and Zaker *et al*. (2016). Nassar *et al*. (2008) found that orange peels contain a high amount of dietary fibre and ash content, while they are low in protein and fat. Magda *et al*. (2008) stated that the orange peels had high ash, ether extract and crude fibre and low protein contents as compared to wheat flour. Hence, using orange peels in bakery products will increase their fibre and ash contents.

Table 1. Physicochemical properties of wheat flour and orange peel powder

| Parameter (%) | Wheat flour | Orange peel powder |
|---|---|---|
| Moisture | 11.27±0.08$^{a}$ | 11.07±0.12$^{a}$ |
| Ash | 1.37±0.09$^{b}$ | 4.13±0.24$^{a}$ |
| Crude protein | 10.90±0.21$^{a}$ | 5.20±0.31$^{b}$ |
| Lipids | 1.80±0.06$^{b}$ | 2.65±0.09$^{a}$ |
| Crude fibre | 0.50±0.06$^{b}$ | 13.20±0.06$^{a}$ |
| NFE$^{*}$ | 85.43±0.17$^{a}$ | 74.82±0.41$^{b}$ |
| Lightness (L) | 87.95±0.50$^{a}$ | 70.67±0.32$^{b}$ |
| Redness (a) | - 0.34±0.14$^{b}$ | 3.59±0.22$^{a}$ |
| Yellowness (b) | 9.31±0.05$^{b}$ | 33.98±0.16$^{a}$ |
| Total phenolic (mg GAE/g) | 1.15±0.25$^{b}$ | 13.94±0.56$^{a}$ |
| Scavenging activity (%) | 2.65±0.64$^{b}$ | 84.33±0.13$^{a}$ |

Values are expressed as mean±SE, n = 3. Values with the same superscript in the same row are not significantly different (P≤0.05). NFE*: calculated by differences.

It was clear that wheat flour has higher (L), lower (a) and (b) at values of 87.95, -0.34 and 9.31, respectively than orange peel powder (Table 1). It is normal for the b value (33.98) of orange peel powder to increase significantly (P≤0.05) because of the existent carotenoids pigments in the albedo layer of orange peels. It could be noticed that orange peel powder are a good source of total phenolic compounds (13.94 mg GAE/g) and it had a great free radical scavenging activity (84.33%) when compared to those in wheat flour. These results are in agreement with those of Rani *et al*. (2020) who confirmed that orange peel powder rich in antioxidants, fibre, and ingredients are good for health and preventing diseases. It could be indicated that bakery products rich in fibre and antioxidants can be developed by incorporating orange peel powder. These results are in agreement with Magda *et al*. (2008).

*3.2 Proximate composition of cookies*

The results in Table 2 indicated that adding orange peel powder to prepared cookies caused a significant (P≤0.05) increase in ash, fibre and lipids with a noticed

 

Table 2. Proximate composition (% on a dry weight basis) of cookies fortified with orange peel powder.

| Cookies samples | Moisture | Ash | Crude protein | Lipids | Crude fibre | NFE |
|---|---|---|---|---|---|---|
| Control | 5.55±0.48$^{a}$ | 1.07±0.07$^{c}$ | 8.80±0.12$^{a}$ | 20.00±0.58$^{c}$ | 0.93±0.02$^{d}$ | 69.21±0.63$^{a}$ |
| Cookie with OPP 5% | 6.10±0.51$^{a}$ | 1.17±0.05$^{bc}$ | 7.73±0.12$^{b}$ | 21.21±0.05$^{b}$ | 1.03±0.04$^{d}$ | 68.68±0.25$^{ab}$ |
| Cookie with OPP 10% | 5.80±0.15$^{a}$ | 1.23±0.03$^{b}$ | 7.13±0.08$^{c}$ | 21.75±0.05$^{ab}$ | 2.00±0.06$^{c}$ | 67.88±0.15$^{bc}$ |
| Cookie with OPP 15% | 5.53±0.22$^{a}$ | 1.32±0.04$^{a}$ | 6.60±0.21$^{d}$ | 21.84±0.03$^{ab}$ | 2.60±0.06$^{b}$ | 67.64±0.12$^{c}$ |
| Cookie with OPP 20% | 5.28±0.01$^{a}$ | 1.35±0.03$^{a}$ | 6.10±0.06$^{e}$ | 22.40±0.06$^{a}$ | 3.63±0.08$^{a}$ | 66.62±0.12$^{d}$ |

OPP: orange peel powder, NFE: calculated by differences. Values are expressed as mean±SE, n = 3. Values with the same superscript in the same row are not significantly different (P≤0.05).

decrease in crude protein and nitrogen-free extract. No significant (P≤0.05) difference was found in moisture content for cookies with orange peel powder compared to the control sample. The low moisture (5.2 to 6.10%) in cookies is an important factor in their long shelf life without spoilage. Gradually, high contents of minerals and crude fibre were found at values of 1.32 and 1.35% and 2.60 and 3.63% with increasing the level of orange peel powder in cookies up to 15 and 20%, respectively when compared with control cookies. This result could be attributed to the high ash and fibre contents of orange peel powder. These findings are in agreement with those reported by Haque *et al*. (2015) and Oladipo *et al*. (2020) who mentioned that the utilization of orange peels in biscuits results in an increase of its contents of fibre and ash.

*3.3 Bioactive compounds of enriched cookies*

Foods rich in phenolic compounds have great attention because of their bioactivity as antioxidant and anticancer agents. The increasing demands of enriched foods led to innovative strategies to enhance the bakeries with phenolic compounds in order to increase their health benefits (Oboh and Adefegha, 2010). From the results presented in Table 3, the per cent of total phenolic compounds of cookies samples was increased significantly (P≤0.05) with increasing the addition of orange peel powder. The highest values of phenolic contents (9.12, 8.31 and 6.10 mg GAE/g) were resulted by substituting wheat flour at 10, 15 and 20% with OPP, respectively as compared to control cookies which recorded 1.15 mg GAE/g. Gadallah and Ashoush (2016) reported that phenolic contents of fortified biscuits were increased gradually with increasing the level of truffle powder addition.

In addition, by their free radical scavenging capacities, all the levels of OPP incorporated in cookies showed significant (P≤0.05) increase and good ability in radical scavenging activity ranged from 4.55% to 40.92%, while it was only 2.65% in the control sample. It is clear that these results are due to the high content of orange peel powder in total phenolic compounds like flavonoids, polyphenols and carotenes (13.94 mg GAE/ g) and antioxidants activity (84.33%). Therefore, it could be concluded that orange peel powder can be considered a natural functional ingredient in bakery goods because of its high antioxidant properties.

Table 3. Total phenolic content and antioxidant activity of enriched cookies samples.

| Cookies samples | Total phenolic (mg GAE/g) | Scavenging activity (%) |
|---|---|---|
| Control | 1.15±0.15$^{d}$ | 2.65±0.73$^{e}$ |
| Cookie with OPP 5% | 5.54 ±0.87$^{c}$ | 4.55±0.27$^{d}$ |
| Cookie with OPP 10% | 6.10±0.64$^{c}$ | 17.48±0.18$^{c}$ |
| Cookie with OPP 15% | 8.31±0.48$^{b}$ | 25.25±0.46$^{b}$ |
| Cookie with OPP 20% | 9.12±0.92$^{a}$ | 40.92±0.35$^{a}$ |

OPP: orange peel powder. Values are expressed as mean±SE, n = 3. Values with the same superscript in the same column are not significantly different (P≤0.05).

These results are in agreement with those found by Ashoush and Gadallah (2011) and Mahmoud *et al*. (2017) who suggested that these antioxidants retarded lipid oxidation during and immediately after the formulation of biscuits. Magda *et al*. (2008) reported that the addition of orange peel powder to biscuits formulations has many advantages as an antioxidant to increase its shelf-life and to enhance the organolep-tic properties of the biscuits, it can also reduce the syn-thetic antioxidants.

*3.4 Physical measurements of cookies*

The effect of substituting wheat flour at 5, 10 15 and 20% with orange peel powder on the physical properties of nutritious cookies was studied and the results are tabulated in Table 4. Substituting wheat flour with OPP resulted in a significant (P≤0.05) decrease in cookie diameter when compared to the control sample (57.33 mm). The diameter values ranged between 53.33 mm and 47.00 mm from the addition of orange peel powder at 5% and 20%, respectively.

Regarding cookie thickness, incorporation of orange peel powder in cookie preparation resulted in a significantly (P≤0.05) high value in thickness ranging from 5.33 to 5.03 mm compared to the control sample of 4.53 mm. These results are in accordance with Bilgicli *et al*. (2007), Zaker *et al*. (2016) and Mahmoud *et al*.

 

(2017). The changes in diameter and thickness are reflected in the spread ratio, it was known that cookies having higher spread ratios are considered most desirable. It was observed that the control cookies have a significantly (P≤0.05) high value in spread ratio of 12.65 as compared to other treatments. No significant difference was found for substituting ratios 5, 10 and 15% with orange peel which recorded 10.00, 9.67 and 9.87, respectively. The lowest value of the spread ratio of 8.98 was given by 20% of replacing per cent. Nassar *et al*. (2008) confirmed that the addition of orange peels negatively affected the physical properties of biscuits, thus the diameter and spread factor were decreased with increasing orange peels level, while the thickness increased.

Table 4. Physical properties of enriched cookies samples with orange peel powder.

| Cookies samples | Diameter W (mm) | Thickness T (mm) | Spread ratio W/T |
|---|---|---|---|
| Control | 57.33±0.88$^{a}$ | 4.53±0.03$^{c}$ | 12.65±0.27$^{a}$ |
| Cookie with OPP 5% | 53.33±1.45$^{b}$ | 5.33±0.07$^{a}$ | 10.00±0.19$^{b}$ |
| Cookie with OPP 10% | 48.66±0.33$^{cd}$ | 5.03±0.03$^{b}$ | 9.67±0.13$^{b}$ |
| Cookie with OPP 15% | 50.00±0.58$^{c}$ | 5.07±0.07$^{b}$ | 9.87±0.17$^{b}$ |
| Cookie with OPP 20% | 47.00±0.58$^{d}$ | 5.23±0.03$^{a}$ | 8.98±0.07$^{c}$ |

OPP: orange peel powder. Values are expressed as mean±SE, n = 3. Values with the same superscript in the same column are not significantly different (P≤0.05).

### *3.5 Colour parameters*

Data in Table 5 describes the colour parameters lightness (L), redness (a) and yellowness (b) for cookies fortified with different ratios of orange peel powder as a source of dietary fibre and antioxidants. The colour of bakery products is an important characteristic of consumer preferences, and it depends on physicochemical parameters of used materials and baking conditions. It could be observed that the control cookies had the highest value of L 72.68, and a gradually significant (P≤0.05) decrement was found in lightness with increasing orange peel levels in the manufacturing of cookies. Within treatments, the maximum lightness of 65.42 was given by 5% of orange peel, while the minimum value of 57.11 was for 20%.

On the contrary, redness (a) and yellowness (b) of cookies sample were significantly (P≤0.05) increased with adding orange peel powder at all studied levels when compared to control which recorded 0.54 and 25.62, respectively. The redness values ranged from 2.25 to 5.69 given by 5% and 20%, respectively, while the yellowness for cookies with 5% being 30.12 and for cookie sample with 20% being 32.66. These results may be due to the slight yellow colour of orange peel powder resulted from carotenoids pigments in the albedo layer and confirmed the yellowness value (a) which recorded 33.98 as found in Table 1. The results are in agreement with Kohajdova *et al*. (2011) and Mahmoud *et al*. (2017). The change in colour of all samples may be due to the browning as a result of Millard reactions compounds formed during drying of peels.

Table 5. Colour parameters of enriched cookies samples with orange peel powder.

| Cookies samples | Lightness (L) | Redness (a) | Yellowness (b) |
|---|---|---|---|
| Control | 72.68±0.39$^{a}$ | 0.54±0.47$^{c}$ | 25.62±0.32$^{d}$ |
| Cookie with OPP 5% | 65.42±0.16$^{b}$ | 2.25±0.31$^{b}$ | 30.12±0.04$^{c}$ |
| Cookie with OPP 10% | 62.07±0.49$^{c}$ | 2.92±0.36$^{b}$ | 30.65±0.24$^{c}$ |
| Cookie with OPP 15% | 58.48±0.03$^{d}$ | 5.35±0.23$^{a}$ | 31.64±0.17$^{b}$ |
| Cookie with OPP 20% | 57.11±0.73$^{e}$ | 5.69±0.18$^{a}$ | 32.66±0.24$^{a}$ |

OPP: orange peel powder. Values are expressed as mean±SE, n = 3. Values with the same superscript in the same column are not significantly different (P≤0.05).

### *3.6 Sensory evaluation of cookies*

Sensory characteristics of prepared cookies with different levels of orange peel powder were evaluated compared to the control sample and the results are found in Table 6. No significant (P≤0.05) difference in the appearance was found during substitute of 5 and 10% of wheat flour with orange peel powder in cookies at values of 8.3 and 7.7, respectively when compared to control cookies (8.1), while the lowest value of appearance (7.2) resulted from 20% of orange peel powder. Data also revealed that all adding levels of orange peel powder did not cause a negative effect on its colour, whereas up to 20% of replacement, the panellists have shown acceptance of the cookie samples in terms of colour. This is probably due to the colour of the peel powder in light yellow as it improves the colour of the samples.

Regarding cookie texture, it is known that adding fruit or vegetable peel powders lead to a slight increase in the hardness of the cookies, and therefore it was found that with increase the substitution rate up to 20%, the value of the texture decreased significantly (6.6) as compared to 8.3 for control cookies. These data are in agreement with Zaker *et al*. (2016) who stated that a slight improvement in the crispiness of cookies was observed in samples up to 10% of peel powder, secured better scores however with 20% of peel powder, the panellists reported dryness of mouth secured least scores. Haque *et al*. (2015) reported that with the increase of

 

Table 6. Sensory characteristics of cookies incorporated with orange peel powder.

| Cookies samples | Appearance (9) | Colour (9) | Texture (9) | Taste (9) | Aroma (9) | Overall acceptability (9) |
|---|---|---|---|---|---|---|
| Control | 8.1±0.23$^{ab}$ | 7.9±0.28$^{ab}$ | 8.3±0.18$^{a}$ | 8.3±0.21$^{a}$ | 8.3±0.20$^{a}$ | 8.4±0.22$^{a}$ |
| Cookie with OPP 5% | 8.3±0.15$^{a}$ | 8.4±0.18$^{a}$ | 8.0±0.15$^{a}$ | 8.2±0.23$^{a}$ | 8.2±0.25$^{a}$ | 8.2±0.20$^{a}$ |
| Cookie with OPP 10% | 7.7±0.33$^{abc}$ | 7.6±0.30$^{b}$ | 7.0±0.26$^{b}$ | 7.6±0.34$^{ab}$ | 7.9±0.35$^{a}$ | 7.7±0.27$^{b}$ |
| Cookie with OPP 15% | 7.5±0.16$^{bc}$ | 7.8±0.11$^{ab}$ | 7.0±0.26$^{b}$ | 7.2±0.26$^{b}$ | 7.4±0.27$^{a}$ | 7.5±0.13$^{b}$ |
| Cookie with OPP 20% | 7.2±0.11$^{c}$ | 7.3±0.20$^{b}$ | 6.6±0.27$^{c}$ | 6.8±0.32$^{c}$ | 7.4±0.31$^{a}$ | 6.9±0.29$^{c}$ |

OPP: orange peel powder. Values are expressed as mean±SE, n = 3. Values with the same superscript in the same row are not significantly different (P≤0.05).

orange fibre, the texture of the cookies has become hard and the acceptability level was decreased.

The results showed no significant (P≤0.05) difference in taste, until a substitution level up to 10% compared to the control (8.3), and an acceptance of the cookies sample containing 15% of orange peel powder was observed (7.2). The lowest taste value 6.8 was recorded by cookies containing 20% of orange peel powder. The bitterness and astringent taste were encountered in cookies as a result of alkaloids, tannins and saponins existence in the orange fruit peel Chikezie *et al*. (2008). Phenolic compounds are known to contribute immensely to the sensory attributes such as flavour, colour and taste flavour of foods (Oboh and Adefegha, 2010). No significant (P≤0.05) effect was observed in its aroma for all treatments with different ratios of orange peel powder as compared to the control sample.

It could be observed that no significant (P≤0.05) difference in overall acceptability between the control 8.4 and cookies incorporated with 5% of orange peel powder were 8.2. The samples were acceptable by the panellists up to 15% of orange peel powder, as no negative effect was shown on the general acceptance of cookies. These data are in accordance with Mahmoud *et al*. (2017) and Khule *et al*. (2019).

## 4. Conclusion

From previous results, it could be concluded that orange peel powder is a vegetable source rich in minerals and dietary fibre, which have many health benefits and can be an abundant source to enhance the nutritional quality of cookies. Cookies incorporated with orange peel powder had a significant increase in radical scavenging activity ranged from 4.55% to 40.92%, these results are due to the high total phenolic content in orange peel powder like flavonoids, polyphenols and carotenes. Therefore, orange peel powder can be considered a natural functional ingredient in cookies because of its high antioxidant ability. The addition of orange peels negatively affected the physical properties of cookies, thus diameter and spread ratio were decreased with increasing orange peels level. All levels of orange peel powder did not cause a negative effect of cookie colour, whereas up to 20% of replacement, the panellists have shown acceptance of the cookie samples. Finally, the orange peel powder could be applied up to 15% as a potential natural source of fibre and bioactive compounds to enhance the nutritional quality of cookies.

## Conflict of interest

The authors declare no conflict of interest.

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