Study of the Functional, Physical and Sensory Properties of Wheat Flour, Orange Peel Powder and Manufactured Biscuits

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ABSTRACT

This study was conducted in the laboratories of the Department of Food Sciences - College of Agriculture - Tikrit University. During the period from August 2021 to January 2022. With the aim of evaluating the functional properties of flour and orange peel powder, a biscuit was also produced with orange peel powder added in rates of 8, 16, 24 and 32%, and evaluation of the physical and sensory properties of the produced biscuits. The experiment was carried out according to a completely randomized design, and the results were as follows: Orange peel powder was distinguished by the highest values significantly compared to wheat flour in most of the functional properties and achieved averages of 9.89 ml water/gm, 5.44 gm water/gm and 1.13 gm oil/gm for the characteristics of swelling ability, water binding capacity and oil binding capacity, respectively. The standard biscuit sample was significantly superior in most of the physical properties and achieved averages of 6.11, 10.43 and 0.45 cm, followed by the 32% biscuits treatment with orange peel powder with averages of 4.57, 15.88 and 0.43 cm for the characteristics of diameter, expansion rate and thickness, respectively. The results of the sensory evaluation showed that the standard sample was significantly superior to all sensory traits except for the color trait, in which the biscuit treatment 8% was superior, which came in the second order significantly, for all traits, while the treatment of biscuits 32% orange peel powder recorded the lowest averages significantly in all traits.

Keywords: Orange Peel Powder, Functional Biscuits, Physical And Sensory Evaluation Of Biscuits.

Introduction

Biscuits show potential as a food enhancer (Nogueira and Steel, 2018) to meet nutritional needs or prevent diet-related diseases. Biscuits offer many possibilities for managing disorders related to human nutrition. They are widely consumed as snacks or as supplements to other foods. They offer varied shapes, pleasant flavors and have a long shelf life (Agama- Acevedo *et al*., 2012). Therefore, the production and consumption of biscuits has increased significantly all over the world (Canalis *et al*., 2017). The widespread consumption of biscuits makes it an ideal product, as it is used as part of nutrition strategies to treat many nutritional and chronic diseases (Singh and Kumar, 2017). Innovations in biscuit techniques and recipes have resulted in a wide range of biscuit products, both in terms of shapes and nutritional properties

(Swapna and Jayaraj Rao, 2016). Biscuits come in many forms and can be enriched with mineral complexes and vitamins or nutrient-rich complementary ingredients, and are made for infants, children, the elderly and those with special needs such as obesity and diabetics (Davidson, 2019). The fortified ability of biscuits and their high consumer acceptance has led them to receive more attention for formulating functional foods or nutrients. Several clinical trials have also been conducted on the efficacy of enhanced biscuits against disease and prevention of chronic and nutritional diseases (Buffière et al., 2020).

Citrus fruits are of global economic importance, and play an important role on the economic front. Citrus fruits contain a variety of health properties and necessary nutrients (Turner and Burri, 2013), due to their richness in vitamin C and folic acid, and they are free of sugar, sodium and cholesterol. Potassium, calcium, thiamine, niacin, vitamin B6, phosphate, magnesium and copper in citrus fruits reduce the risk of heart disease, various types of cancer and respiratory diseases, as well as reduce the risk of epidemics such as COVID-19 in humans (Bellavite and Donzelli, 2020).

The demand for more sustainable practices towards implementing a circular economy in the food system is a key strategy for the future. Thus, most studies focus on improving the ability to extract nutrients from by-products and use parts of them in the production of new functional foods (Romeo et al., 2020). In this context, citrus is considered one of the most important fruit crops in the world with an annual production exceeding 122.5 million tons, and a third of the crop is industrially processed to produce juices, jams or to extract essential oils. In citrus processing, peel residues are the primary waste fraction, amounting to approximately half of the total weight of the fruit (Wang et al., 2015). So the use of novel functional ingredients recovered from food by-products could be a viable alternative to formulate products with high added value (Pasqualone et al., 2014). Among baked products, biscuits can be a viable and acceptable candidate for adding functional ingredients (Ismail et al., 2014).

Market competition and the recent increase in demand for healthy products with low calories and high fiber content have stimulated research trends aimed at raising the nutritional value of baked products such as biscuits by adding fiber, creating many opportunities for the use of by-products such as the use of fruit peels. and thus highlights the importance of the research by improving the nutritional value of the resulting biscuits and improving their quality by adding orange peel powder by 8, 16, 24 and 32%. Study of functional properties of orange peel powder. Evaluation of the physical and sensory properties of the resulting biscuit.

Materials and methods

This study was conducted in the laboratories of the Department of Food Sciences - College of Agriculture - Tikrit University, and the following materials and methods were used to achieve it:

Materials for making biscuits: The following materials were used in the manufacture of the biscuits (wheat flour with an extraction rate of 72%, powdered sugar in a household electric grinder, hydrogenated vegetable oils, sodium chloride, low-fat milk powder and bread improver powder), which were obtained from the local markets of the city of Tikrit.

Prepare orange peel powder: After obtaining the Egyptian variety Washington navel orange from the local markets of the Tikrit city during the month of August / 2021, the fruits were washed with tap water and the stuck water was disposed of after the end of the cleaning. For the second time, since the presence of juice and pulp on the peels encourages the growth of microbes, then it was subjected to solar drying for several days until the proper humidity was reached, then it was ground with an electric grinder and then the orange peel powder was sieved using a vibrating sieve type Matest, the holes of which were 250 micrometers, and the powder was packed in vacuum bags. from the air (Ajila *et al*., 2008).

Biscuit manufacturing: The biscuit was prepared according to Manley (2000) using the ingredients and quantities mentioned in Table (1):

Table 1: Ingredients of the mixture used per 100 weight units of flour for preparing biscuits

Flour	**100**	**Low fat dried milk**	**1.4**
Water	**19**	**Table salt**	**1**
Crushed sugar	**25**	**Baking powder**	**2**
Hydrogenated vegetable ghee	**20**		

Biscuit manufacturing process steps:

1- Added sugar first, then fat, mixing well, then add water with baking powder, then flour and orange peel powder according to the studied rates, and the rest of the ingredients and knead well until the ingredients are homogeneous and the gluten network develops.

2- Leave the dough to rest for 45 minutes.

3- Transferred the dough to a baking tray lined with parchment paper, and spread it out to a thickness of 3.5 mm.

4- The rolling process was repeated in successive stages with decreasing thickness, as the thickness of the dough in the first individual started from 15-20 mm and decreased until it reached the final thickness, which ranged between 2-3 mm.

5- Cut up using a circular cutter.

6- Baked using an oven at 210-215°C for 8-10 minutes.

7- After baking, the cooling process was slow, until the temperature of the biscuit reached room temperature.

8- It was packed in bags and left until the required analyzes are carried out or consumption (Ajila *et al*., 2008).

Study treatments

The study included adding five levels of orange peel powder to the biscuit dough, and these levels are: 0 = the control treatment (without adding orange peel powder), while the remaining four treatments included adding orange peel powder at the rate of 8, 16, 24 and 32% to the biscuit dough.

Studied characteristics

Functional properties of orange-peels

Swelling capacity: It refers to the average volume occupied by the sample immersed in an excess amount of water after equilibrium over the actual weight, and it was estimated according to what was mentioned by (Robertson *et al*., 2000) with some modifications, where 0.2 gm of scale powder was taken and moistened with 10 ml of distilled water in a test tube. At room temperature, after equilibrium for 18 hours, the volume reached and weight after drying were recorded.

Capacity to swell = volume taken by sample (ml)/dry weight of sample (g)

water retention capacity: It is the largest amount of water that one gram of the substance can absorb or retain under low sedimentation velocity, and was estimated according to the instructions (AACC, 2000) with some modifications, where 0.1 g of peel powder was taken and moistened with 10 ml of distilled water at room temperature in a test tube 15 ml, then it was mixed for 5 minutes, then left to rest for 30 minutes at room temperature, then the test tube was placed in a centrifuge at 2000 rpm for 10 minutes, the supernatant was removed and the residue was weighed before drying, Then it was dried in an electric drying oven at 105° C until the weight was stable.

Water binding capacity = Weight of wet residue (g) - Weight of dry residue (g) / Weight of dry residue (g)

The oil holding capacity: Ten ml of corn oil was added to 100 mg of the sample in a 15 ml test tube, then the mixture was stirred and then placed in a centrifuge at 1600 rpm for 25 minutes, and the ability to bind the oil was expressed as the number of grams of oil retained by 1 g from the sample (Ocen *et al*., 2013).

Physical tests: These tests were carried out to determine the physical characteristics such as diameter, thickness and rate of expansion, as 6 pieces of edge biscuits were placed on the edge to calculate the diameter using a scale, then the pieces were rotated at an angle of 90˚ and the diameter was calculated and the rate was taken (cm), and to measure the thickness, the pieces were placed on top of each other and then measured, and then Rearrange again and measure again and calculate the rate (cm), and the rate of expansion = diameter ÷ thickness (AACC, 2000).

Sensorial tests: Sensory tests were conducted in the laboratories of the Department of Food Science/College of Agriculture/Tikrit University, and sensory samples of biscuits were evaluated by (20 people) according to the sensory evaluation form shown in Table (2), which determined the general acceptance-preference of the studied sensory traits. (Shape, texture, taste, smell, color, general acceptance and sensation after chewing) by conducting the questionnaire according to the (Nine-point Hedonic Scale) method mentioned in (Ajila *et al*., 2008), which is based on giving samples numbers from (9-1), which range from 9 = I like it very much to 1 = I never liked it

Table (2): Sensory evaluation form.

The sample: …………………………								
Traits / Evaluation		**Shape**	**texture**	**taste**	**smell**	**color**	**general acceptance**	**sensation after chewing**
1	**I never liked it**							
2	**I didn't like it very much**							
3	**I kind of didn't like it**							
4	**I didn't like it a bit**							
5	**I neither reject nor accept it**							
6	**I like it a little**							
7	**I kinda like it**							
8	**I like it very much**							
9	**I like it very much**							

Statistical analysis: After collecting the data, it was entered on the computer and then sorted using the Excel program, and it was statistically analyzed using the statistical analysis system (SAS) version ninth, as a normal experiment according to the Complete Randomize Design (CRD), then a comparison was made between the means of the treatments using the least significant difference (LSD) method, according to Al-Zubaidy and Al-Falahe (2016)

Results and discussion

Functional properties of used wheat flour and orange peel powder

Table (3) shows the results of examining the ability to bloat and water binding for each of the flour and orange peel powder, as it is noted that the swelling ability was 3.94 and 9.89 ml water/ gm, respectively, in previous studies the swelling ability of orange peel powder reached

10.7 ml of water/g in a study of Jamal (2016), while Figuerola *et al*. (2005) obtained 6.11 ml water/gm average bloating ability for oranges, for apples 8.27 ml water/gm, and for grapes 8.02 ml water/gm, while Ocen and Xu (2013) obtained 11 ml water/g of orange peel powder.

As for the ability to bind water to flour and orange peel powder, it was 3.3 and 5.44 gm water/ gm, as for the results of previous studies, it reached in the Jamal study (2016) for orange peel powder, it reached 5.65 gm water / gm, and in the study of Lario *et al*. (2004). On orange peel powder, it reached 6 gm water/gm.

Miskiewicz *et al*. (2018) indicated that the ability of dough ingredients to bind with water was improved in the presence of lemon peel powder, which reduced water evaporation in the baking process. The ability to bind water in orange peels increases due to the high content of soluble fibers as well as the high content of pectin substances due to the hydrophilic properties of the pectin materials, and the moisturizing properties of the fibers are due to its ability to bind water through its structure (Navarro-González *et al*., 2011), It binds with water through two mechanisms, the first: the water is trapped within the capillary structure as a result of surface tensile forces, and the second: through bonding with component molecules by hydrogen bonds and dipole molecules (Daou and Zhang, 2011). As the high amount of fiber in orange peel powder leads to an increase in the ability to bind water, due to the structural properties and chemical composition of the fibers that affect the kinetics of permeable water, as the surface tensile forces facilitate the binding of water in the capillary structure of the fibers, which affects the interaction of water with compounds. molecular through hydrogen or polar bonds. The porous structure of orange peel powder allows for greater swelling, as bonds are formed with water through calcium bridges between pectin molecules and bridges between ferulic acid and hemicellulose

Table (3) Functional properties of used wheat flour and orange peel powder.

Functional properties	Flour (72%)	Orange peel powder	LSD ($P\leq0.05$)
Swelling capacity ml water/gm	**3.94 b**	**9.89 a**	**4.13**
Water binding capacity gm Water/gm	**3.3 b**	**5.44 a**	**1.37**
Capacity to bind oil gm oil / gm	**1.66 a**	**1.13 a**	**0.61**

The values followed by the same letter are not significantly different from each other according to the LSD test.

The ability to bind water and swell is affected by the size of the particles, a lowering the particles size lead to increase the ability to bind water, due to the increase in the specific surface, revealing polar groups and many hydrophilic sites, and the increase in the percentage of soluble fibers, especially pectin substances, which have bonds that can disintegrate with greater potential to bind to water molecules within it through calcium bridges, allowing more water retention (Benítez *et al*., 2011). Thus, the higher capacity for water absorption and swelling enhances the possibility of using orange peels as a component of low-calorie foods (Chau *et al*., 2007).

Table (3) shows the ability of flour and orange peel powder to bind oil, which did not show a significant difference between them in this trait, and the averages reached 1.66 and 1.13 gm oil / gm, respectively. The ability to bind oil affects the oil retention in food, and the hydrophobic part is considered the water in the substance is mainly responsible for this indicator, and from previous studies, the ability to bind the oil in orange peels was 1.6 gm oil/gm dry matter, and these results are close to those obtained by Figuerola *et al*. (2005), which amounted to 1.2 gm oil/ gm for grapes, lemon 1.3 gm oil/ gm, and apple 1.45 gm oil/ gm. This property is useful for the stability of foods containing high levels of oil.

Physical properties of biscuits produced by adding orange peel powder

The results of Table (4) showed that there were slight effects of adding orange peel powder and the rates of its addition to the biscuit dough on the physical properties of the produced biscuit. As for the diameter characteristic whose results are shown in Table (4), the addition of orange peel powder differed significantly from the standard sample rate that It excelled with an average of 6.11 cm, but the powder addition percentages did not differ significantly between them despite the decrease in the diameter rate with the increase in the percentage of addition. These results are consistent with many previous studies that found that the diameter rate decreased by increasing the percentage of orange peel powder or other fruit residues, as in the study of Jamal (2016), which indicated a decrease in the diameter rate of the biscuits produced by increasing the percentage of adding orange peel powder. The study of Mahmoud *et al*. (2017) showed that the biscuit diameter gradually decreased with the increase in the level of orange peel powder replacement. They showed that the highest significant value was for the control and 5% added biscuits, with averages of 5.08 and 5.07 cm, respectively, while the lowest value was found for the prepared biscuits with a percentage of 20% orange peel and reached 4.60 cm. Ajila *et al*. (2008) obtained the same effect when mango peels were added to biscuits. Kohajdovà *et al*. (2011) obtained the same effect when apple pomace was added to biscuits. Sudha *et al* (2007) also obtained a reduction in diameter when barley bran was added to biscuits. The study of Hernández-Ortega *et al*. (2013) on biscuits by adding 30% of microwave-dried carrot pomace, showed that in the standard sample structure, the crystallized starch granules are caught through the protein texture, while in the case of adding orange peel powder, the fiber particles stick to the starch and protein granules, as a result of gelatinization, some starch grains lose their shape, and the development of the gluten network may be slowed.

Table (4): Physical composition of biscuits containing different percentages of orange peel powder

Treatment / Physical properties	Standard sample	Biscuits produced with orange peel powder				LSD (P≤0.05)
		8 %	16 %	24 %	32 %	
Diameter (cm)	**6.11 a**	**4.88 b**	**4.79 b**	**4.68 b**	**4.57 b**	**0.33**
Expansion **rate (cm)**	**10.43 c**	**9.86 d**	**10.20 cd**	**11.23 b**	**15.88 a**	**0.38**
Thickness (cm)	**0.45 a**	**0.46 a**	**0.49 a**	**0.42 a**	**0.43 a**	**0.35**

The values followed by the same letter for each variable are not significantly different from each other.

For the characteristic of the rate of expansion, which is one of the important tests that are carried out on biscuits, it is noted from Table (4) that there are significant differences between the studied treatments in which the treatment of high percentage of addition 32% recorded the highest expansion rate of 15.88 cm, while the treatment of addition rate of 8% achieved the lowest rate of value 9.86 cm, followed by 16% addition rate with 10.2 cm without significant difference from the standard sample which recorded 10.43 cm. These results are close to obtained by Jamal (2016) when adding orange peel powder, that the expansion rate was 11.6 cm to the standard sample without significant differences from the low addition percentage of 5%, it showed an increase in the expansion rate with an increase in the level of orange peel powder, and attributed this to the change in the diameter and thickness values. Mahmoud *et al*. (2017) showed that the expansion coefficient is the ratio that depends on the values of the biscuit thickness and diameter, and their results showed that the expansion rate gradually decreased with the increase of the orange peel powder replacement level from 5-20% of the additives, while the highest significant value was observed for the control sample 0%. The expansion rate of the biscuit T0 (control) was 9.31 cm, and this value decreased after adding orange peel to the biscuit to range from 8.99 to

7.48 with 5 and 20% orange peel additions, respectively.

Table (4) shows the thickness rates for the biscuit samples under study to which different percentages of orange peel powder are added, which did not differ significantly from each other and their values ranged between 0.42 and 0.49% at the percentage of addition of 24% and 16%, respectively, and the standard sample achieved an average thickness was mediator among the different percentages of addition, it was 0.45 cm. Uysal *et al.* (2007) stated that the decrease in thickness is due to the decrease in the proportion of gluten present in flour mixtures, which leads to a decrease in the puffiness of the dough. Also, the interaction between fiber and gluten leads to a decrease in the ability to hold gas (Sudha *et al.*, 2007), and it is noted that the presence of fiber is due to the inhibition of the development of the dough structure and the reduction of carbon dioxide (CO_2) gas retention, in addition, the presence of fiber reduces the amount of water available during biscuit manufacturing, and consequently, the lack of water needed for the development of the gluten-starch network, which causes the gluten network to not develop and reduces the thickness and volume (Jamal, 2016). This increases the percentage of hydrophilic sites in the polysaccharides, including pectin, which competes for the free water in the dough, affecting the dough's swelling (Ajila *et al.*, 2008).

Sensory evaluation of biscuits produced by adding orange peel powder

The results of the sensory evaluation of the biscuits produced by adding orange peel powder, which are shown in Figure (1) and Table (5), showed that the standard sample was significantly superior in all the sensory attributes under study except for the color attribute, in which the treatment of biscuits with orange peel powder was superior by 8%, while the 8% addition treatment ranked second significantly for all traits except for the smell, which recorded the lowest values significantly, while the biscuits treatment with orange peel powder added by 32% recorded the lowest mean significantly in all studied traits.

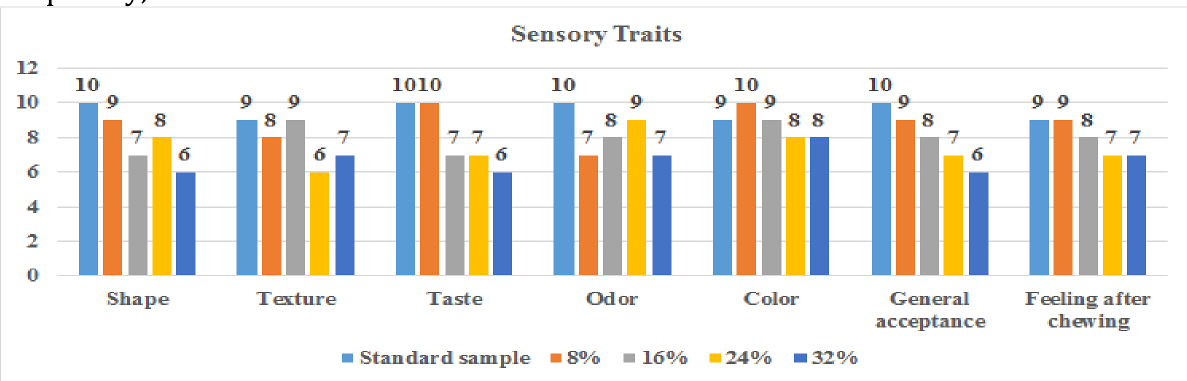

Figure 1: Sensory evaluation of biscuits produced by adding orange peel powder.

It was noted that the characteristics of taste, color, general acceptability and post-mastication sensation were all decreased by increasing the percentage of orange peel powder addition. Surface color is an important quality component, which affects the acceptability of baked goods made with wheat (de Abreu *et al.*, 2019). Even if the baking parameters may affect the color of the baked food due to the added ingredients as well (Yilmaz and Karaman, 2017). The final color in baked products is the result of chemical reactions, such as the Maillard reaction, which consists of non-enzymatic brown reactions that are affected by the amount of reducing sugars in foodstuffs and by baking temperature (Friedman, 2015), and caramel (Purlis and Salvadori, 2007). These results are in agreement with what was obtained by Imeneo *et al.* (2021) of an increase in the darkening of the color of the biscuit samples and a decrease in the brightness due to the influence of Maillard and caramelization reactions that occur during the baking process. Borrelli *et al.* (2003) also reported that the interaction between proteins and carbohydrates is the cause of the final brown color.

The addition of orange peel powder showed changes in the external shape, as the increase in the percentage of addition led to an increase in the appearance of cracks, and this case was also observed in the study of each of Jamal (2016) when adding orange peels to biscuits, and Magda *et al*. (2008) when mandarin peels are added to biscuits. As for the shape, texture and smell, we find that they behaved irregularly, while Jamal (2016) mentioned that the biscuit with an added percentage of 15% of orange peel powder and above, became more hard, as its hardness increased with the increase in the percentage of adding the powder, as mentioned by Haque *et al*. (2015) when orange pulp powder was added to biscuits, the hardness of the texture increased with the increase in the percentage of addition. The reason for the increase in hardness when adding a powder with high levels of fiber is the decrease in the amount of gluten in the dough, as well as the thickness of the walls surrounding the air bubbles, and the high moisture content of the biscuit dough added to it increases the hardness, as the dough with a higher moisture content produces tougher biscuits (Ajila *et al*., 2008). The cracking phenomenon of biscuits is higher in products with higher moisture content, and the ability to bind water to soluble fibers such as pectin is higher than to insoluble fibers such as cellulose. When evaluating the taste of the biscuits prepared by adding orange peel powder, it was noticed that the bitter taste increased with the increase in the percentage of addition, due to the presence of limonene in the citrus peels, which is the main responsible for the orange flavor, and the presence of high concentrations of it makes the biscuit not suitable for consumer taste (Romero-Lopez *et al*., 2011). This result is consistent with the findings of Jamal (2016) that the bitter taste increased by increasing the concentration of orange peels to 15% and above.

Table (5): Sensory evaluation of biscuits containing different percentages of orange peel powder

Treatments / sensory traits	Standard sample	Orange peel powder				LSD (P≤0.05)
		% 8	% 16	% 24	% 32	
Shape	**10 a**	**9 b**	**7 d**	**8 c**	**6 e**	**0.79**
Texture	**9 a**	**8 b**	**9 a**	**6 d**	**7 c**	**0.82**
Taste	**10 a**	**10 a**	**7 b**	**7 b**	**6 c**	**0.67**
Odor	**10 a**	**7 d**	**8 c**	**9 b**	**7 d**	**0.54**
Color	**9 b**	**10 a**	**9 b**	**8 c**	**8 c**	**0.49**
General acceptance	**10 a**	**9 b**	**8 c**	**7 d**	**6 e**	**0.95**
Feeling after chewing	**9 a**	**9 a**	**8 b**	**7 c**	**7 c**	**0.87**

The values followed by the same letter for each variable are not significantly different from each other.

As for the smell of biscuits prepared by adding orange peels, the smell of orange was noticed, but it was favored at the percentage of addition of 24%, and it decreased when the percentage of other additions, while the opinion of the residents was divided into those who consider it a strange smell than the well-known smell of biscuits, and among those who considered it rich in the smell of fruit and sings about adding any other flavors. With regard to the color of the biscuits, it was noted that the standard sample was creamy yellowish, while it was observed that a yellow color appeared in the resulting biscuits when orange peel powder was added, due to the pigments present in those peels, and the darkening of this color increased with the increase in the percentages of addition. It was also found that the method of solar drying adopted with orange peels has preserved the basic characteristics such as color and smell.

In general, the high percentage of orange peel powder addition led to a decrease in the general acceptance of the biscuit, and this was in agreement with what was obtained by Jamal (2016) Ocen and Xu (2013) when the high percentage of orange peel powder was added to the biscuit dough. The bitter taste appears immediately when tasting the biscuit prepared with the addition of orange peels, but there is a feeling of bitterness in the mouth after tasting.

We conclude from the above that adding 8% orange peel powder produced a biscuit that was sensory-acceptable to the product compared to the standard sample. While the results reflected improving the nutritional properties of the resulting biscuit (Ashush and Gadallah, 2011), it was also observed that adding 10% of orange by-products did not affect the sensory acceptability of the product known as Muffin (Romero-Lopez et al., 2011).

Conclusion: The orange peel powder has good functional properties represented in its high ability to swell and bind water and oil. The addition of orange peel powder to the biscuit gives the possibility to preserve the physical and sensory properties. It is noticed that the addition of orange peel powder to the biscuits improved the sensory properties of the biscuits produced at the low percentage of 8%, while it caused a decline in the sensory properties of the biscuits produced at the high percentage, especially at the percentage of 32%.

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