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Preparation of orange peel biscuits enrich with phenolic compounds as natural antioxidants.

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ABSTRACT

Bakery products especially, biscuit are widely consumed because of their availability easy to eat convenience. Chemical corruption is considered the limiting factor because it's high percentage of fat content. Synthetic antioxidants are very effective for lipid oxidation retardation with regarding its carcinogenic effect. The main objective of the study was preparing of biscuit blends containing different concentrations (5, 10, 15 and 20%) of orange peel powder as natural source of bioactive compounds (antioxidant). The application of orange peel as food additive in preserving biscuit with regarding their effect on the chemical and physical properties. The chemical composition (moisture, protein, ash and fat), baking quality (diameter, thickness, spread ratio and spread factor), physical characteristics (pH value, color), function properties (water holding capacity WHC and oil holding capacity OHC), total phenolic, thiobarbituric acid (TBA) and sensory attributes of biscuit samples were evaluated. The addition of orange peel powder to biscuits represents on improvement in their nutritional properties one way analysis of variance (ANOVA). Data showed that the incorporation of orange peel in biscuits formula increased ash content, while protein and fat content were decreased. The thickness of biscuits was increased, whereas diameter spread factor and spread ratio of biscuits decreased with increasing levels of orange peel. The pH values of samples were increased by the addition of orange peel, while color properties of biscuits were significantly ($P< 0.05$) decreased. The biscuits substituted with orange peel powder had higher values of both of WHC and OHC. Total phenolic content was increased significantly ($P< 0.05$) by increasing orange peel levels, while TBA values were decreased. Highly acceptable biscuits could be obtained by incorporating T3 (15%) orange peel in the formulated biscuit. It be concluded that the orange peel incorporated into biscuits exhibited antioxidant properties and emphasis the lipid peroxidation suppression of orange peel additives in addition to its good effect on other attributes. Therefore, T3 (15 %) orange peel powder supplemented biscuits could be recommended to be produced as biscuits with good quality acceptable sensory and quality attributes.

Keywords: *Orange peel, biscuits, proximate composition, backing quality, physical characteristics, pH, color, total phenolics,* thiobarbituric acid*, sensory evaluation.*

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INTRODUCTION

Biscuit is the most widely consumed preferable bakery products because of their availability easy to eat convenience, with regarding its long shelf life[1]. Biscuits, among all bakery products, are more significant since they are vastly used as snacks by children and adult[2]. Also, low moisture content of biscuit is playing an important role for keeping-out of microbial spoilage[2] but still fast and easy corruption by the chemical spoilage because its high percentage of fat content. Recently, many attempts are being made to improve the functionality and quality attributes, as well as nutritional qualities so that they can compete viciously in the markets to those of other products in addition to health and natural functions, taking into account the economic cost effective manner[3]. For that, keeping great quality of biscuit is the more important economic target.

Lipid oxidation can be prevented and delayed by the addition of antioxidants. The uses of synthetic antioxidants were applied for certain foods but, this has been restricted to extent sometimes as a result of its toxic and carcinogenesis effects on health[4]. A new trend in food processing is the use of natural antioxidants from plant source[5,6] or waste of food processing to be good alternatives of synthetics, in addition to their added values as providing bioactivity of biscuit to introduce a new functional food[7].

Citrus is one of the most important crops in the world that represent large amount of waste (about 50% of hall fruit)[8]. Therefore, the functionality of peel components, flavonoids, pectin and carotenoids should be studied[9].

Obtained data from previous study indicated that, the citrus peel is our interest because of its high content and sheep source of bioactive components. The citrus by-products had a high amount of bioactive compounds varied from Vit. C, ß-carotene and total phenolic content. The effect of variety and drying methods on bioactive compounds amount of peels were investigated previously[10,11]. Valencia orange had the highest amount of bioactive compounds and antioxidant activities. The microwave was the best method for drying the citrus by-products with regarding to bioactive compounds and its antioxidant activities[10,11].

Accordingly, citrus by-products are promising source of bioactive compounds which are offering new commercial opportunities for food industry. However, to date there are very scarce information and studies on by-products and their applications in biscuits, which is an important area of research.

Therefore, the main objective of the present study was to processing biscuits prepared from different concentrations (5, 10, 15 and 20%) of orange peel powder in addition to control as a source of natural antioxidants in biscuits and their effect on quality characteristics of biscuit.

MATERIALS AND METHODS

Materials: Orange peel was obtained from ripen and freshly oranges (*C. Valencia,*) prepared and dried according to Marwa *et al.,*[10]**.** Wheat flour (72% extraction), sugar powder, baking powder, vanilla- flavoured sugar, eggs and margarine were purchased from the local market, Cairo, Egypt.

Chemicals: All used chemicals and reagents were (Sigma, Aldrich &Fluka) purchased from Sigma, Aldrich &Fluka Chemical Co. (St. Ouis, Mo, 63103 USA). All other chemicals and reagents used were of analytical grade. The used water was distilled using water distillation apparatus (D 4000).

Preparation of dough and baking biscuits

Dry ingredients were mixed together and then combined with others according to the recipe presented in Table 1. The dough was mixed for 10 min to obtain a homogeneous consistency and then placed into the fridge at 6 °C over a period of 30 min. The dough was sheeted to a thickness of about 3 mm using rolling machine. The sheeted dough was cut into round shape using a 45 mm diameter cutter and baked on an aluminum trays in an electric oven at 180 ºC for 6 minutes. The supplemented biscuits with orange peel powders were prepared using the same formula except for replacing the wheat flour was added at four levels 5, 10, 15 and 20 % orange peel powder in the same way as the control sample (biscuits without orange peel) in the biscuit was cooled for 30 minutes, packed in polyethylene bags stored under desiccation[12].

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Table 1. Components used for the preparation of biscuit dough

Components (g)	/ T0	T1	T2	T3	T4
Wheat flour	100.0	95.0	90.0	85.0	80.0
Margarine	45.0	45.0	45.0	45.0	45.0
Sugar powder	26.7	26.7	26.7	26.7	26.7
Eggs	10.0	10.0	10.0	10.0	10.0
Vanilla-flavoured sugar	5.3	5.3	5.3	5.3	5.3
Baking powder	0.7	0.7	0.7	0.7	0.7
Orange peel powder (%)	0.0	5.0	10.0	15.0	20.0

T0: (Control) T1: (5 % orange peel powder) T2: (10 % orange peel powder)
T3: (15 % orange peel powder) T4: (20 % orange peel powder)

Proximate analysis of formulated biscuit

Biscuits were analyzed for moisture, protein, fat and ash content determined according to the methods described in the AOAC[13]**.** All determinations were performed in triplicates and the means were reported.

Baking quality of formulated biscuit

For the determination of diameter (width), thickness (height), spread ratio (SR) and spread factor (SF), AACC[14] methods

Physical characteristics of formulated biscuit

pH value: Were measured using pH meter (model Cyber Scan 500).The pH was measured by according to the method of AOAC[13]**.**

Color measurements

Color of the baked biscuits was measured. Hunter a, b and L parameters were measured by a color difference meter using a Sspectro- colorimeter (Tristimulus Color Machine) with the CIE lab color scale (Hunter, Lab Scan XE - Reston VA, USA) in the reflection mode. The instrument was standardized each time with white tile of Hunter Lab Color Standard (LX No.16379): X= 72.26, Y= 81.94 and Z= 88.14 (L*= 92.46; *a= -0.86; *b= -0.16) [15].The color difference (Δ E*) were calculated according to the method of Palou *et al*., [16] as follows: $\Delta E^* = (\Delta a^2 + \Delta b^2 + \Delta L^2)½$.

Function properties of formulated biscuit (Water & oil holding capacity)

Water and oil holding capacity for biscuits was determined as described by Garau *et al*.,[17]**.** The water holding capacity (WHC) was expressed as the number of grams of water held by 1 g of sample. The oil holding capacity (OHC) was expressed as the number of grams of oil held by 1 g of sample.

Determination of total phenolic compounds

The Folin-Ciocalteu assay, adapted from Ramful, *et al.,*[18] was used for the determination of total phenolics present in the citrus fruit extracts.

Determination of thiobarbituric acid (TBA) of formulated biscuits

The amount of lipid oxidation in different substituted biscuits was determined by the 2-thiobarbituric acid (TBA) method according to Vynce[19]. Absorbance was measured at 538 nm. The values reported were averages of three measurements, and the results were expressed as mg of malonaldehyde /kg of biscuit samples.

Sensory evaluation of biscuits

The evaluation the quality and acceptability of the biscuits (0, 5, 10, 15 and 20 %) orange peel using panelists of ten well-trained judges, the sensory evaluation was carried out for colour, taste, odour, flavour and overall- acceptability. Biscuits were evaluated using a 10-point hedonic scale (1-dislike extremely to 10=like extremely). The rating scale was used for all other parameters according to method described by Larmond[20].

Statistical analysis

The data obtained from study and sensory evaluation was statistically subjected to one way analysis of variance (ANOVA) and means separation was by Snedecor and Cochran[21].The least significant difference (L.S.D) value was used todetermine significant differences between means and to separate means at $p \leq 0.05$ using SPSS package version 15.0

RESULTS AND DISCUSSION

Chemical composition of formulated biscuits

Proximate composition of biscuits substituted with orange peel powder is presented in Table 2. The analysis of variance for treatments indicated that moisture, ash, protein and fat content were found significantly different (P< 0.05) among all treatments. It was seen that there is marked effect of orange peel proportion on moisture content in the sample containing 20 % orange peel (T4) comparing to control sample. The Ash content of orange peel was presented in table 2. The maximum ash content was found in the sample containing 20 % orange peel (T4) comparing to control sample in the control sample (T0). These results are in agreement with those reported by Marin et al.,[22].

Table 2. Chemical composition (% on dry weight) of wheat flour biscuits formulated with different concentrations of orange peel powders

Treatments	Moisture %	Ash %	Protein %	Fat %
T0 (whole wheat flour)	0.21 ± 0.01^{e}	0.77 ± 0.58^{c}	8.52 ± 0.31^{a}	27.32 ± 0.34^{a}
T1 (5 % orange peel powder)	$1.17^{c}\pm0.02$	$0.85^{bc}\pm0.15$	$7.19^{b}\pm0.86$	$26.57^{ab}\pm0.77$
T2 (10 % orange peel powder)	$2.08^{b}\pm0.22$	$1.05^{bc}\pm0.23$	$6.41^{b}\pm0.30$	$25.65^{b}\pm0.69$
T3 (15 % orange peel powder)	$2.59^{d}\pm0.02$	$1.32^{ab}\pm0.02$	$6.30^{b}\pm0.34$	$23.98^{c}\pm0.53$
T4 (20 % orange peel powder)	$3.41^{a}\pm0.21$	$1.66^{a}\pm0.12$	$6.24^{b}\pm0.05$	$23.01^{c}\pm0.51$
LSD at 5 %	0.33	0.54	1.33	1.07

-All values are means of triplicate determinations ± standard deviation (SD).
- Means within column with different letters are significantly different at (P<0.05).

On the other hand, protein content was significantly decreased (P< 0.05) with increasing orange peel powder substitution in biscuits. It was found that minimum protein content was observed in treatment T4 comparing to control sample T0. Also, fat content of orange peel powder fortified biscuits significantly decreased (P< 0.05) with increasing orange peel powder. The fat content was found minimum in the T4 (20 %) orange peel. It was found maximum in the sample containing T0 (control). This might be due to the results of the lower protein and fat contents of citrus by-products [23, 22].

Baking quality of formulated biscuits

Physical characteristics (diameter, thickness, spread ratio and spread factor) of orange peel powder fortified biscuits were studied. The mean values of physical characteristics of biscuits are presented in Table 3. Diameter of the biscuit showed gradual decrement with increasing the level of orange peel powder replacement. Data revealed that highest significant (P< 0.05) value was observed for the biscuits prepared from T0 (control) and T1 (5%) (5.08 and 5.07 cm, respectively), whereas lowest values were found biscuits prepared from T4 (4.60).

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Table 3. Physical characteristics of wheat flour biscuits formulated with different concentrations of orange peel powders

Treatments	Diameter (cm)	Thickness (cm)	Spread ratio	Spread factor
T0 (whole wheat flour)	5.08^{a}± 0.38	0.55^{e}±0.02	9.31^{a}±1.03	93.06^{a}±10.4
T1 (5 % orange peel powder)	5.07^{a}±0.12	0.57^{d}±0.02	8.99^{ab}±0.88	90.05^{ab}±8.72
T2 (10 % orange peel powder)	5.05^{a}± 0.08	0.58^{c}±0.04	8.69^{ab} ±0.65	87.03^{ab}±6.48
T3 (15 % orange peel powder)	4.70^{b}±0.21	0.60^{b}±0.02	8.01^{bc}±1.39	79.97^{bc}±9.13
T4 (20 % orange peel powder)	4.60^{b}±0.23	0.61^{a}±0.04	7. 48^{c}±0.59	74.84^{c}.±8.02
LSD at 5 %	**0.23**	**0.44**	**1.14**	**11.34**

-All values are means of triplicate determinations ± standard deviation (SD).
- Means within column with different letters are significantly different at (P<0.05).

On the other hand, the thickness of the biscuits prepared from the composite flour containing orange peel powder varied significantly (P < 0.05) whereas, thickness of T0 (control) biscuit was 0.55 cm. The addition of orange peel was increasing the thickness by increasing the level of orange peel powder replacement from T1 (5 %) to T4 (20 %) (Table 3). The highest value (0.61 cm) was found in T4 (20 %). The spread ratio for T0 (control) biscuits was 9.31, these value was decreased after the addition of orange peel to biscuit to be ranged from 8.99 to 7.48 with 5% and 20% orange peel additives respectively. However, spread factor is the ratio which depends on the values of biscuit thickness and diameter. The mean spread factor of the sample of biscuits is shown in Table 3. The results showed that the spread factor gradually decrease as increasing the level of orange peel powder replacement (from 90.05 to 74.84 in orange peel at 5-20 % levels of additives, respectively), while, the highest significant (P< 0.05) value 93.06 was observed for the control sample T0. The same trend was observed by Bilgicli et al.,[23].

Physical characteristics of formulated biscuit

pH values of formulated biscuits

Results indicated that the addition of orange peel caused a significant decreased (P< 0.05) in pH values of samples (Table 4). Whereas, increasing orange peel levels resulting in decreased pH values which ranged from T1 (7.76) to T4 (7.59) comparing to control sample (7.76). That decrement in pH values could be attributed to the acid nature of orange peel as a result of its organic acid contents; these results were in agreement with Alesón-Carbonell *et al*.,[24]**.**

Table 4. Physico-chemical properties of wheat flour biscuits formulated with different concentrations of orange peel powders

Treatments	Ph value	Color			
		L*	a*	b*	ΔE *
T0 (whole wheat flour)	7.97^{a}±0.02	69.81^{a}±0.02	11.12^{a}±0.17	35.10^{a}±0.17	43.60^{c}±0.19
T1 (5 % orange peel powder)	7.76^{b}±0.03	69.06^{b}±0.02	8.89^{b}±0.02	34.05^{b}±0.02	42.04^{d}±0.02
T2 (10 % orange peel powder)	7.72^{c}±0.03	67.21^{c}±0.17	9.20^{b}±0.36	33.53^{b}±0.47	43.35^{c}±0.55
T3 (15 % orange peel powder)	7.64^{d}±0.02	66.19^{d}±0.02	9.40^{b}±0.58	34.05^{b}±0.63	43.61^{b}±0.88
T4 (20 % orange peel powder)	7.59^{e}±0.02	63.83^{e}±0.02	10.55^{a}±0.11	34.81^{a}±0.43	46.63^{a}±0.40
L.S.D at 5 %	**3.54**	**0.17**	**0.58**	**0.74**	**0.92**

-All values are means of triplicate determinations ± standard deviation (SD).
- Means within column with different letters are significantly different at (P<0.05).
L*= lightness a*= redness b*=yellowness

Color characteristics of formulated biscuit

Color is the most important quality parameters for fruits. The changes of fruit color were caused by the degradation of its ingredients[25]. Therefore, study the effect of the incorporation of orange peel powder on color characteristics of biscuits was considered. The effect of biscuits formulated with different concentrations

of orange peels on color properties of biscuits represented in Table 4. Data showed that addition of orange peel decreasing significantly (P< 0.05) the lightness (L*) value where the concentration T3 was (63.83), compared with the control sample T0 (69.81). That behavior may be due to pectin content of orange peel. On the other hand, the redness (a*) were significantly decreased (P< 0.05) in concentration T1 (8.89) & T2 (9.2) when compared with control samples T0 (11.12), but its increased one more time in T3 (9.4) & T4 (10.55). Yellowness was also decreased significantly (P< 0.05) from 34.05 to 33.53, at concentrations 5 %, 10 %, while it was increased one more time at the concentrations 15 % and 20 %, it was 34.81 and 34.05, respectively when compared to control samples T0 (35.10). The trend of ΔE* (color difference) was as increasing gradually by increasing orange peel levels. The records of ΔE* for orange peel powder concentration at T3 and T4 were 46.63 and 44.63, respectively compared with the control T0 (43.60). The change of color observed in all sample may be due to the browning which happened in samples as a results of Millard reaction compounds formed during drying of peels[26].

Function properties of formulated biscuit

Water holding capacity (WHC) and oil holding capacity (OHC)

WHC & OHC are essential physiological and technological properties which indicate the behaviors and quality attribute of any additives applied in bakery products. These properties are related to the chemical structure of peel polysaccharides and depend on surface properties, overall charge density, thickness, and hydrophobic nature of the fiber particle[27].

The water holding capacities (WHC) and oil holding capacities (OHC) of biscuits substituted with orange peel powder is presented in Table 5. The obtained results show that there were a significantly differences (P<0.05) among all treatments, whereas increasing orange peel powder substituted biscuits resulted in higher values of WHC and OHC. WHC value was found in the range between 2.65 to 2.87 g water/g sample in samples ranged from 5% to 20% orange peel additives, respectively) comparing to control sample T0 (2.63 g water/g sample) Table 5. On the other side, it is evident that the OHC value of orange peel biscuits found in range between (1.77 to 1.88 g oil/g sample in samples from 5% to 20% additives, respectively) comparing to control sample T0 (1.75 g oil/g sample). It could be noticed that orange peel additives increasing both of WHC and OHC values for biscuits which results in improving its quality attributes. These values are similar to those measured by Garau, et al.,[17].

Table 5. Water holding capacity (WHC) and oil holding capacity (OHC) of wheat flour biscuits formulated with different concentrations of orange peel powders

Treatments	WHC g water/g dried sample	OHC g oil/ g dried sample
T0 (whole wheat flour)	2.63^{c}±0.02	1.75^{bc}±0.02
T1 (5 % orange peel powder)	2.65^{bc}±0.07	1.77^{c}±0.01
T2 (10 % orange peel powder)	2.75^{b}±0.02	1.82^{ab}±0.02
T3 (15 % orange peel powder)	2.76^{ab}±0.02	1.84^{b}±0.02
T4 (20 % orange peel powder)	2.87^{a}±0.02	1.88^{a}±0.02
L.S.D at 5 %	**0.11**	**0.02**

All values are means of triplicate determinations ± standard deviation (SD).
- Means within column with different letters are significantly different at (P<0.05).

The total phenolic content of formulated biscuits

Phenolic compounds are known to contribute immensely to the sensory attributes such as flavor, color and taste flavor of foods[28]. Furthermore, diets rich in phenolic compounds have a great attention because of its bioactivity as antioxidant and anticancer agents. That increasing demands of enrich our diet with phenolics are led to innovative strategies to enhance the diet with phenolic compounds in order to take its health benefits. Total phenolics of citrus peel were determined in order to evaluate its effect on inhibition of lipid oxidation of biscuit in addition to its role as natural bioactive compounds in biscuit to be an easy to eat source of functional food. The results of the total phenol content of formulated biscuits, as gallic acid equivalent (GAE) are shown in Table 6. Results showed that there was a significant increase (p < 0.05) in total

phenol content among all treatments reflecting that addition of orange peel led to increasing the total phenols content of biscuit.

Table 6. Total phenols (mg/100 g sample) of wheat flour biscuits formulated with different concentrations of orange peel powders

Treatments	Total phenols (mg/100 g sample)
T0 (whole wheat flour)	10.64^{e}±0.54
T1 (5 % orange peel powder)	17.15^{d}±0.30
T2 (10 % orange peel powder)	23.63^{c} ±0.13
T3 (15 % orange peel powder)	27.81^{b}±0.15
T4 (20 % orange peel powder)	41.21^{a}±0.30
L.S.D at 5 %	**0.58**

-All values are means of triplicate determinations ± standard deviation (SD)
- Means within column with different letters are significantly different at (P<0.05).

The total phenolics content of biscuit were ranged from 17.15 mg/100 g in 5% orange peel additives T1 to reach 41.2121 mg/100 g at orange peel percentages additive of 20% T4 in biscuit samples, comparing to control sample which was T0 (10.64 mg/100 g sample). This suggested that much of phenolic compounds may have originated from incorporation of orange peel.

Lipid oxidation (Thiobarbituric acid TBA value) of formulated biscuits

There is no doubt that TBA value is considered a good indicator for the oxidation of lipid by forming malonaldehyde (MDA). For that, TBA value is considered the major chemical determination of secondary lipids oxidation[29].

Results in Table 7 represented TBA values of biscuit with different orange peel additives. Data showed that increasing orange peel levels resulted in decreasing (P< 0.05) TBA values compared to the control, which reflect that the orange peel incorporated into biscuits exhibited antioxidant properties and emphasis the lipid peroxidation suppression of orange peel additives. The lowest TBA value was obtained at 20% orange peel additives in biscuit samples T4 (0.170 mg malonaldhyde/kg sample) whereas, the highest values was seen at 5% orange peel additives T1 (0.164 mg malonaldhyde/kg sample) compared to control samples T0 (0.38 mg malonaldhyde/kg sample), Table 7. These results suggested that these antioxidants retarded lipid oxidation during and immediately after formulated of biscuits. Wan *et al*.,[30] reported that citrus by products have associated bioactive compound (flavonoids, polyphenols, carotenes) with antioxidant properties. Previous reports revealed the antioxidant and antidiabetic properties of orange peels[31].

Table 7. TBA values (mg/kg) of wheat flour biscuits formulated with different concentrations of orange peel powders

Treatments	TBA values (mg malonaldhyde /kg)
T0 (whole wheat flour)	0.380^{a}±0.02
T1 (5 % orange peel powder)	0.354^{ab}±0.02
T2 (10 % orange peel powder)	0.345^{b}±0.02
T3 (15 % orange peel powder)	0.288^{c}±0.03
T4 (20 % orange peel powder)	0.270^{c}±0.02
L.S.D at 5 %	**0.02**

-All values are means of triplicate determinations ± standard deviation (SD).
- Means within column with different letters are significantly different at (P<0.05).

The aforementioned results showed that orange peel is considering a promise material for new functional food (biscuit) product, as it is enhancing the nutritional value of food, in addition of being strong antioxidant. This can indicate that marked antioxidant activity of orange peel in biscuit seem to be the result of their radical scavenging activity and reducing power.

Correlation between Lipid oxidation (TBA) and total phenolic compounds

There was a high reversed significant (P<0.05) correlation between total phenol content and TBA. That correlation was (-0.94), which reflected that total phenolic substances are responsible for retarding of lipid oxidation in biscuit samples, in addition to its role in decreasing thiobarbeturic acid reactant substances (TBA) formation by reacting with that molecules and decreasing its level in biscuit samples.

Sensory evaluation

Table (8) summarizes the results of the sensory evaluation of biscuits samples formulated with different concentrations of orange peel. Data indicated that there were significant differences (P<0.05) between samples for the sensory attributes of color, taste, odour, flavour and overall- acceptability and the control biscuits sample. Results showed that the biscuits with T3 (15 %) orange peel had the highest score of overall- acceptability for all sensory characteristics were (8.8) followed by T1 (8.6). However, these formulations had higher acceptance value than did the biscuits made with T2 and T4 orange peel. These results are in agreement with those reported by Nassar et al.,[32].

Table 8. Sensory evaluation of biscuits formulated with different concentrations of orange peel powders

Treatment	Color	Taste	Odour	Flavour	Overall acceptability
T0 (whole wheat flour)	$8.8^{a}\pm0.84$	$8.9^{a}\pm0.83$	$9.0^{a}\pm0.71$	$9.1^{a}\pm0.13$	$9.0^{a}\pm0.83$
T1 (5 % orange peel powder)	$8.0^{c}\pm0.82$	$8.2^{c}\pm0.81$	$7.7^{bc}\pm0.14$	$8.4^{c}\pm0.34$	$8.6^{ab}\pm0.82$
T2 (10 % orange peel powder)	$7.4^{e}\pm0.14$	$7.6^{d}\pm0.89$	$7.4^{bc}\pm0.51$	$7.6^{bc}\pm0.88$	$8.0^{b}\pm0.88$
T3 (15 % orange peel powder)	$8.2^{b}\pm0.48$	$8.7^{b}\pm0.54$	$8.8^{ab}\pm0.84$	$8.6^{b}\pm0.55$	$8.8^{a}\pm0.83$
T4 (20 % orange peel powder)	$7.9^{d}\pm0.16$	$5.4^{e}\pm0.58$	$6.4^{c}\pm0.15$	$7.4^{bc}\pm0.89$	$6.2^{c}\pm0.71$
L.S.D at 5 %	**1.23**	**1.13**	**1.45**	**1.42**	**1.21**

-All values are means of triplicate determinations ± standard deviation (SD).
- Means within column with different letters are significantly different at (P<0.05).

These results reflected that the orange peel powder could be added amount up to 15 % in formula biscuits with adversely affecting sensory characteristics of biscuits. Generally, the preference of biscuits by panelists was associated with the low level bitterness. It the reason why biscuit samples (T0 & T1) received the highest score as it was less bitter than other biscuits. The bitterness and astringent taste were encountered in biscuits as a result of alkaloids, tannins and saponins existence in the orange fruit peel[33]. Therefore, T3 (15 %) orange peel powder supplemented biscuits could be recommended to be produced as biscuits with good quality acceptable sensory quality attributes.

CONCLUSION

In the present study, proximate composition, physical characteristics, color, total phenolic content, thiobarbituric acid (TBA) and sensory quality attributes of biscuit with orange peel additives at different levels. The addition of orange peel was resulting in decreased TBA value, which indicates that the orange peel incorporated into biscuits exhibited antioxidant properties and suppression the lipid peroxidation of biscuit samples. Highly acceptable biscuits could be obtained by incorporating T3 (15%) orange peel in the formulation. Therefore, 15 % orange peel powder supplemented biscuits could be recommended to be produced as biscuits with good quality and acceptable sensory quality attributes.

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