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# Study the Effects of replacement different percentages of pomegranate peels in the manufacture of cookies and its impact on the chemical, physical, sensory properties and antioxidant activity of the produced cookies

## ABSTRACT

The experiment was conducted in the laboratories of the Food Science Department - College of Agriculture - Tikrit University, the study aimed to produce cookies by replacing the wheat flour with the pomegranate peels by 0, 1.5, 3, 4.5%, and study its impact on the chemical, physical, sensory properties and antioxidant activity of the produced cookies. The results of replacing cookies with different percentages of pomegranate peels showed a change in the chemical estimates of its components, as the proportions of moisture, ash, fat, protein, fiber and carbohydrates for the control sample ($T_O$) (4.13, 0.58, 22.64, 6.89, 0.54, 65.22) %, and (3.56, 0.61, 22.12, 6.84, 0.80, 66.07) % for the sample ($T_1$) replaced by 1.5% pomegranate peel, and (3.48, 0.65, 21.97, 6.78, 0.95, 66.17) % for the sample ($T_2$) replaced with 3% pomegranate peels, And (3.36, 0.69, 21.79, 6.71, 1.18, 66.27)% for the sample ($T_3$) replaced with 4.5% pomegranate peels. The effect of substitution on the physical properties of the cookie product, it showed a significant decrease in the diameter of the additive sample of 1.5, 3, and 4.5% of the pomegranate peel, reaching 4.71, 4.66 and 4.56 cm, respectively, and a decreased in the thickness with increasing the concentration, as the thickness reached (1.41, 1.36, 1.35, 1.33) cm for the parameters $T_0$, $T_1$, $T_2$, and $T_3$, respectively, while, the diffusion ratio was 3.46, 3.45 and 3.43 cm for T1, T2, and T3 parameters, respectively. The results of estimation of phenols indicated that the concentration of total phenols in the cookies product was 74.92 mg/100 g, 78.89 mg / 100 g, 83.39 mg/100 g, and 88.85 mg/100 g for samples ($T_0$, $T_1$, $T_2$, $T_3$), respectively, while the percentage for free radical inhibiting activity in cookies samples with different concentrations of pomegranate peels added was 21.20% in the control group ($T_0$) and in the treatments $T_1$, $T_2$ and $T_3$ (24.07, 25.18 and 27.12), respectively. The results of the sensory evaluation of the cookie product under study showed, transaction $T_1$ outperformed the rest of the transactions in overall product acceptance, the results showed that there were no significant differences ($P \leq 0.05$) in the taste quality between the treatments ($T_0$, $T_1$, $T_2$) and also between the two treatments ($T_2$, $T_3$), The results also showed that there were no significant differences between the treatments ($T_0$, $T_1$) and the coefficients ($T_1$, $T_2$), and between the treatments ($T_2$, $T_3$) in the color, while the results showed that there were no significant differences in the parameters $T_0$, $T_1$, $T_2$ and T3 for the crispiness, also, the results showed of the sensory evaluation that were no significant differences ($P \leq 0.05$) between all treatments for the characteristics of texture and overall acceptability.





## INTRODUCTION

Pomegranate tree is one of the oldest Edible Fruits trees, which was mentioned in the Quran. Its fruits also contain high concentrations of multiple phenolic compounds compared to other fruits. Pomegranate, whose scientific name is *punica granatum*, belongs to the *punicaceae* family, and its cultivation is now widespread in Asia, Europe, North and South America, Africa and Australia (Holland *et al.*, 2009).

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Pomegranate consumption has increased result its multiple functions and nutritional benefits, pomegranate is usually consumed in several forms, either fresh or processed, such as juices, jams, jelly and others. The edible portion of the pomegranate fruit represents about 50%, consisting of 40% aril and 10% seeds, the inedible portion represents the peels and amounts to about 50% of the total weight of the fruit, the consumption of these fruits usually generates large quantities of by-products, these include peels, which are often disposed of as waste and can be used in the food and pharmaceutical industries (Jalal., 2018; Balli., 2020).

Pomegranate peel contains abundant quantities of bioactive compounds, the peel of pomegranate contains large quantities of phenolic compounds such as flavonoids, catechins, anthyocyanins, tannins, pedunculagin, punicalin, and gallic acid (Ismail *et al.* 2012; Sood and Gupta, 2015).

Phenolic compounds are used in the food industry as natural colorants, preservatives, antioxidants, or additives of nutritional value, and interest in them has increased because to their multiple health benefits free radical scavenging capability, many researchers have also studied the effect of adding pomegranate peels and extracts in many food products, including dairy products, meat products, fish and cookies, and their effect on chemical, physical and sensory properties and antioxidant activity. In another study, the potential use of pomegranate peel in muffin cakes was studied. Wheat flour was partially (5, 10, and 15%) substituted with pomegranate peel powder. Pomegranate peel powder increased apparent viscosity values of cake batters. Pomegranate peel addition caused a significant ($P \leq 0.05$) increase in insoluble and total dietary fibers, total phenolics, and total antioxidant activity values (Topkaya and Isik,2019). In another study, pomegranate peel powder supplementation significantly ($P \leq 0.05$) improved dietary fibers (0.32–1.96 g/100 g), total phenols (90.7–161.9 mg GAE/100 g) and inorganic residues (0.53–0.76 g/100 g) of cookies. Similarly, significant increase in Ca, K, Fe and Zn levels was noted in supplemented cookies (Ismail *et al.* 2014).

## MATERIALS AND METHODS

### 1 - Source of samples

Pomegranate fruits were obtained from the local variety (Punica granatum var.nana) during the month of August of 2019 from the local markets of Salah El-Din Governorate.

### 2 - Prepare of pomegranate peel powder

Pomegranate peel powder was prepared according to Ranjitha *et al.* (2018b).

**2-1: Pre-treatment:** Fresh pomegranate peels were cut into small pieces using a steel knife, treated by soaking in 2% saline solution for 10 minutes, then, the saline solution was discarded and the peels were washed with tap water, then placed in trays and dried.

**2 -2: Prepare the peel powder:** After pretreatment fresh pomegranate peel was placed in a tray drier at 65 ºC for several hours how many to obtain dry peel, the dried pomegranate peel was crushed by food grinder in to powder form to completely pass through 0.5 mm size sieve to obtain a homogeneous powder.

### 3- preparation of cookies product:

The cookies product was manufactured according to the method mentioned by El-sharnouby *et al.* (2012) with some slight modifications with the adoption of different concentrations of peel and flour, and shown in Table (1), 100gm of flour (or flours and peels) is mixed, with 25g of fat, 30g of sugar, and 1.5g of sodium bicarbonate, and 2 grams of ammonium bicarbonate and 0.4

grams of table salt dissolved in a small amount of water, and Skimmed milk powder 2 gm was made into suspension with water, Total volume of water was limited to 25 ml. The liquid and solid ingredients were well mixed and a paste was formed. Then it she divided the dough into small balls, the dough was rolled and sheeted to a thickness of 3.5 mm thick and 45 mm in diameter and placed on greased trays, baked at a temperature of 190±20oC for 8-10 min in oven, after baking, cookies were left to cool at room temperature, and then kept in plastic containers with a tight lid at the temperature of the refrigerator until the tests were carried out.

Table (1) Flour and pomegranate peel ratios used in the preparation of cookies

| Treatment | Flour ratio | Peels ratio | The total content of flour and peels |
|---|---|---|---|
| **Control** | 100 | zero | 100 |
| **T1** | 98.5 | 1.5 | 100 |
| **T2** | 97 | 3.0 | 100 |
| **T3** | 95.5 | 4.5 | 100 |

4- **Chemical estimation of cookies product:**

**A- Determination of moisture ratio**:

The moisture content of the cookies product was estimated according to the method mentioned in AOAC (2005).

**B- Determination of ash ratio:**

Estimated approval of the standard method mentioned in AOAC (2005).

**C- Determination of fat ratio:**

Estimate according to the method described in AOAC (2005) using the succulite unit.

**D- Determination of protein ratio:**

The nitrogen content of the cookies product was estimated according to the method mentioned in AOAC (2005) by the standard Kjeldahl method, and the protein percentage was calculated by multiplying the percentage of nitrogen in the samples by the conversion factor of 6.25.

**E- Determination of total carbohydrate ratio:**

The percentage carbohydrates were calculated according to the method mentioned by Pearson (1970) as the difference between the sum of the components represented by the percentage of moisture, ash, fat and protein minus 100.

**F- Determination of fiber:**

The fibers were determined according to the method mentioned in AACC (2000).

**5- Physical Properties:**

Physical properties were measured which included thickness, width and spread rate as reported by Ranjitha *et al.* (2018).

**6- Estimation of total phenolic content and antioxidant activity in a cookie product:**

**A- Prepare of sample:**

Take 1 gm of the cookies samples study and add 50 ml of methanol of 60% in an Erlenmeyer flask, and mixture was shaken vigorously for 5 minutes at room temperature, the mixture was centrifuged at 3500 rpm for 10 min, the supernatant was collected for analyses.

**B- Estimation of total phenols:**

Total phenols were estimated according to the folin-ciocalteu method reported by Roy *et al.* (2014).

**C- Determination of antioxidant efficacy**

The antioxidant efficacy of the cookies was estimated by estimating the inhibitory effect of free radicals and according to a method described by Chakraborty and Bhattacharyya (2019).

**7- Sensory Evaluation of Cookies product:**

The sensory evaluation of cookies made in the laboratory was carried by 18 evaluators of professors and students of food science - University of Tikrit. Evaluation forms for sensory characteristics, and the evaluation scores were calculated using a grading system from (1 to 9-Point hedonic scale) and as mentioned in Ismail *et al.* (2014).

## RESULTS AND DISCUSSION

**1. Chemical properties of cookies:**

Table (2) showed significant differences at the level (P≤0.05) between samples and for all components, and it also showed that the percentage of moisture in the cookie product fortified with pomegranate peel powder in proportions (1.5, 3, 4.5) % reached (3.56, 3.48, 3.36). Respectively, while reached 4.13% in the control group ($T_0$). This result agrees with the description that given by Ismail et al. (2014), as they indicated that the moisture content of the cookies fortified with pomegranate peels was (4.35, 4.30, 4.24, 4.17%) for samples with pomegranate peelings added to the proportions (0, 1.5, 3, 4.5) % Respectively, it also converges with that mentioned by Ismail *et al.* (2016 a). The ash percentage was (0.58, 0.61, 0.65, 0.69) % for samples (T0, T1, T2, and T3) respectively, and the results showed a significant increase (P≤0.05) in the percentage of ash with increasing concentration. and these results are close to was mentioned by Ismail and others (2014), as they indicated that the percentage of ash in the cookies fortified with pomegranate peelings was (0.53, 0.55, 0.61, 0.67) grams / 100 grams for samples supported with concentrations (0, 1.5, 3, 4.5) % respectively. The percentage of fat in the cookie product to reached 22.64% in the control group (T0), while it reached (22.12, 21.97 and 21.79%) for the samples (T1, T2, and T3), respectively, as a significant decrease was noticed at the level (P≤0.05) in Fat percentage when increased concentrations. converge these results with Ismail *et al.* (2014), amounting to (23.78, 23.64, 23.59, 23.51) g / 100 g samples (0, 1.5, 3, 4.5%) respectively. The percentage of protein was (6.89, 6.84, 6.78 and 6.71) % for the samples (T0, T1, T2, and T3), respectively. These results were similar to was reported by Ismail et al. (2016 a). Table (2) also includes the percentage of fiber in the samples of the cookies product, and also notes a significant increase at the level of (P≤0.05) in the percentage of fiber when the concentrations of pomegranate peels added to the product increased, as the percentage of fiber reached (0.80, 0.95 and 1.18%) for the samples. (T1, T2, and T3) respectively, while the percentage of fiber was 0.54% in the control group (T0). The percentage of carbohydrates, is noticed a significant increase (P≤0.05) for samples (T0, T1, T2, T3), as it reached (65.22, 66.07, 66.17 and 66.27%), respectively. The reason for the difference in the proportions of carbohydrates in the samples may be attributed to the difference in the proportions of the other components, as the carbohydrates were estimated according to the difference between the components.

Table (2) The chemical composition of the cookies product containing different percentages of pomegranate peel

| Components / Treatment | Moisture % | Ash % | Fat % | Protein % | Fiber % | Carbohydrates % |
|---|---|---|---|---|---|---|
| T0 | a4.13 | d0.58 | a22.64 | a6.89 | d0.54 | d65.22 |
| T1 | b3.56 | c0.61 | b22.12 | b6.84 | c0.80 | c66.07 |
| T2 | c3.48 | b0.65 | c21.97 | c6.78 | b0.95 | b66.17 |
| T3 | d3.36 | a0.69 | d21.79 | d6.71 | a1.18 | a66.27 |

- The numbers in the table refer to three-repeat rates
- Differences in lowercase letters indicate a significant effect at ($P \leq 0.05$).
- The sample represents T0 (control group), T1 (1.5% pomegranate peel + 98.5% flour), T2 (3.0% pomegranate peel, +97% flour), T3 (4.5% pomegranate peel + 95.5% flour).

The difference in the proportions of the ingredients compared to what was mentioned in the previous studies, it may be attributed to the difference in the variety used to obtain the peel, the difference in the variety may mean the difference in the proportions of these components in the shells originally, and thus the difference in their proportions in the product made from them, to the difference in the proportions used from the peels, the quality difference in the flour used, difference in chemical components, the degree of extraction, and the type of wheat, difference in the of added water percentage, and peel of pomegranate is dry in nature, and increase the addition percentage from, it may lead to the absorption of a higher percentage of added water this is indicated by Srivastava *et al.* (2014).

**2. The physical properties of cookies:**

The show physical properties of the cookies product, which include width, thickness and spread rate, shown in Table (3), significant differences ($P \leq 0.05$) between some of treatments. It was also evident that there was a significant decrease in the diameter of the sample containing 1.5% of pomegranate peels (T1), reaching 4.71 cm compared with the control sample (T0) of 4.91 cm. Also, the two samples T3 and T4 differed significantly, containing (3 and 4.5) % of Pomegranate peels, was compared to the comparison treatment, as its diameters were (4.66 and 4.56) cm respectively. These results are consistent with Ranjitha *et al.* (2018b) reported as they observed a decrease in the width in the cookies product fortified with different concentrations, including (2.5% pomegranate peels + 25% defatted soybean flour, 5% pomegranate peel + 30% defatted soybean flour), It is also consistent with Ajila *et al.* (2008) mentioned, when they indicated a decrease in the width of the biscuit product supported with different concentrations of mango peels, including (0, 5, 7.5, 10, 15, 20%), Zaker *et al.* (2016) stated that adding orange peels at (0, 5, 10, 15, 20%) concentrations to the product of cookies led to a decrease in the width with an increase in the concentrations.

Table (3) showed that there were no significant differences ($P \leq 0.05$) between some treatments in thickness, noting that there was a slight decrease in thickness at lower concentrations of the peels, and a higher decrease with increasing concentration, the thickness reached (1.41, 1.36, 1.35, 1.33) cm for T0, T1, T2 and T3 treatments respectively. This result agrees with the description that given by Ajila *et al.* (2008) reported as they observed a decrease in the thickness of the biscuit product with different concentrations that included (0, 5, 7.5, 10, 15, 20%) of mango peels. This result agrees with reported by Ranjitha *et al.* (2018b). The reason for the decrease in thickness with increasing concentrations of pomegranate peel powder may be due to the decrease in gluten, this result agrees with reported Zaker *et al.* (2017).

Table (3) The physical characteristics of cookies product containing different proportions of pomegranate peel

| Treatments | Width (cm) | Thickness(cm) | Spread ratio |
|---|---|---|---|
| **T0** | 4.91 a | 1.41 a | 3.48 a |
| **T1** | 4.71 b | 1.36 b | 3.46 b |
| **T2** | 4.66 c | 1.35 b | 3.45 b |
| **T3** | 4.56 d | 1.33 c | 3.43 c |

- The numbers in the table refer to three-repeat rates
- Differences in lowercase letters indicate a significant effect at (P≤0.05).
- The sample represents T0 (control group), T1 (1.5% pomegranate peel + 98.5% flour), T2 (3.0% pomegranate peel, +97% flour), T3 (4.5% pomegranate peel + 95.5% flour).

Also found that the changes in width and thickness are reflected in spread ratio, It reached 3.38 in the control sample, while the T1 sample was 3.46, and this value decreased until it reached 3.43 with an increase in the addition of pomegranate peel powder, this is because of change in the diameter and thickness values. This result agrees with Zaker *et al.* (2016), when they indicated that the changes in diameter and thickness were reflected in the rate of spread in the cookies product, as they noticed a decrease in the spread rate when adding concentrations of orange peel powder was increased.

**3. The content of total phenols in the cookies product:**

Table (4) showed significant differences (P≤0.05) between all samples, total phenols concentration in the cookies product was 74.92 mg/100 g, 78.89 mg /100 g, 83.39 mg /100 g, and 88.85 mg /100 g for samples T0, T1, T2 and T3, respectively. These results converged with of Ismail et al. (2016 a) they reported that the phenols content was 75.19 mg gallic /100 gm, 78.35 mg gallic /100 gm, 82.47 mg gallic /100 gm, and 87.53 mg gallic /100 gm in the cookies samples supplemented with pomegranate peels ratio (0, 1.5, 3, 4.5) % respectively, and with the findings of Ismail *et al.* (2014). The variation in total phenols content ratios attributed this product in cookies to add pomegranate peel at different concentrations, the phenolic content increased with the increased concentration of pomegranate peel added, it may also have attributed the difference between has been reached and reported in other studies to several factors, The genetic characteristics of pomegranate fruits, growth conditions and storage methods, as well as the difference in the method used in preparation of samples used in the pomegranate peel cookies product manufacturing process, drying method, temperature, time used and devices used, This is consistent with was indicated by ovigasogie *et al.* (2009) there are many different factors that affect the total phenolic content, such as plant variety, treatment during harvest, storage methods and working mechanisms during the analysis process.

Table (4) The phenolic content and the percentage of antioxidant activity in cookies supplemented with different proportions of pomegranate peels

| Treatments | Total phenolic content (mg GAE/100g) | Antioxidant activity DPPH % |
|---|---|---|
| **T0** | 74.92 a | 21.20 d |
| **T1** | 78.89 c | 24.07 c |
| **T2** | 83.39 b | 25.15 b |
| **T3** | 88.85 a | 27.12 a |

- The numbers in the table refer to three-repeat rates
- Differences in lowercase letters indicate a significant effect at (P≤0.05).
- The sample represents T0 (control group), T1 (1.5% pomegranate peel + 98.5% flour), T2 (3.0% pomegranate peel, +97% flour), T3 (4.5% pomegranate peel + 95.5% flour).

**The antioxidant efficacy in the cookies product**

Table (4) showed the percentage of free radical inhibiting activity in samples of cookies with different concentrations of pomegranate peel added, the percentage in the control group (T0) was 21.20%, and in the treatments T1, T2 and T3 (24.07, 25.18 and 27.12) % respectively. These results are in agreement with the findings of Ismail et al. (2016a) they stated that activity of inhibiting free radicals in the cookies supplemented with pomegranate peels was (22.14, 23.21, 24.80 and 26.66) % in the samples supplemented with rates (0, 1.5, 3, 4.5) % respectively, these results converged with reported by Ismail *et al.* (2014). The increased addition of pomegranate peel powder in the cookies product increased the antioxidant capacity because the total phenolic content is high in the pomegranate peel, although some phenolic compounds are lost as to the baking process (Nasser and AL Diab, 2018). The importance of phenolic compounds that they are powerful natural antioxidants that can be used in many food and pharmaceutical applications, the presence of these phenolic compounds high concentrations in pomegranate peels, which are by-products of the manufacturing processes, it makes of great importance by recycling wastes and utilizing these as alternatives to industrial antioxidants and as food additives. The work some phenols as antioxidants to their oxidative properties, so they work as reducing agents or hydrogen donors, and have the ability to suppress free radicals (Hakkim *et al.* 2008). There are other factors that are taken into consideration, such as the nature and structure of these compounds (Heim *et al.* 2002). The characteristics of antioxidants depend on the structural properties of the phenolic molecules and their basic composition (Čiž *et al.*2010).

**Sensory evaluation of the cookies product**

Table (5) showed the results sensory evaluation of the cookies product, treatments outperform (T1) on the rest treatments in overall acceptance product, the results showed that were no significant differences (P≤0.05) in the taste quality between the treatments (T0, T1, T2) and also between treatments (T2, T3). The results showed no significant differences between the treatments (T0, T1) and between treatments (T1, T2), and treatments between (T2, T3) in the color characteristic. the results showed that no significant differences between T0, T1, T2 and T3 for the crispiness characteristic, the results show of sensory evaluation no significant differences (P≤0.05) between all transactions for texture and overall acceptance. The table shows the superiority of the treatment (T1) over the rest of the treatments for the studied four characteristic. The findings of the sensory evaluation also converge with the findings of Ismail *et al.* (2014) the decrease in the sensory evaluation was observed when increasing the concentration of pomegranate peel added to the cookies product.

Table (5) Sensory evaluation results of a cookies product supplemented with different proportions of pomegranate peels

| Treatments | taste | color | crispiness | texture | overall acceptance |
|---|---|---|---|---|---|
| **T0** | 7.11 a | 8.00 a | 7.33 a | 7.39 a | 7.27 a |
| **T1** | 7.00 a | 7.00 ab | 7.44 a | 7.11 a | 7.44 a |
| **T2** | 6.67 ab | 6.50 bc | 7.28 a | 6.89 a | 7.00 a |
| **T3** | 5.94 b | 5.72 c | 6.89 a | 6.89 a | 6.83 a |
| **Mean** | 6.68 | 6.81 | 7.24 | 7.07 | 7.14 |

- Similar lowercase letters within a single column no significant differences at P≤0.05.
- Each evaluation has ten marks.

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## دراسة تأثير استبدال نسب مختلفة من قشور الرمان في تصنيع الكعك الصغير المحلى وتأثير ذلك على الخواص الكيميائية والفيزيائية والحسية والنشاط المضاد للأكسدة للكعك المنتج

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**المستخلص**

أجريت التجربة في مختبرات قسم علوم الأغذية– كلية الزراعة – جامعة تكريت وهدفت الدراسة الى تحضير منتج الكعك الصغير المحلى وذلك بأستبدال طحين الحنطة بقشور الرمان بالنسب 0، 1.5، 3، 4.5%، ودراسة تأثير ذلك في الخواص الكيميائية والفيزيائية والحسية والنشاط المضادة للأكسدة للكعك المنتج. وبينت نتائج استبدال الكعك بنسب مختلفة من قشور الرمان تغيراً في التقديرات الكيميائية لمكوناته إذ بلغت نسب كل من الرطوبة والرماد والدهن والبروتين والالياف والكاربوهيدرات لعينة السيطرة ($T_O$) (4.13، 0.58، 22.64، 6.89، 0.54، 65.22) % و (3.56، 0.61، 22.12، 6.84، 0.80، 66.07) % للعينة ($T_1$) المستبدلة بـ 1.5 % قشور رمان، و (3.48، 0.65، 21.97، 6.78، 0.95، 66.17) % للعينة ($T_2$) المستبدلة بـ 3 % قشور رمان، و (3.36، 0.69، 21.79، 6.71، 1.18، 66.27) % للعينة ($T_3$) المستبدلة بـ 4.5 % قشور رمان. اما تأثير الاستبدال في الخصائص الفيزيائية في منتج الكعك، فقد أظهرت حصول انخفاضاً معنوياً في القطر للعينة المضاف اليها 1.5و 3 و4.5% من قشور الرمان إذ بلغت 4.71 و4.66 و4.56 سم على التوالي، وانخفاضاً في السماكة مع زيادة التركيز، إذ بلغت السماكة (1.41، 1.36، 1.35، 1.33) سم للمعاملات T0، T1، T2، T3 على التوالي، بينما بلغت نسبة الانتشار 3.46 و3.45 و3.43 سم للمعاملات $T_1$، $T_2$، $T_3$ على التوالي. أشارت نتائج تقدير الفينولات ان تركيز الفينولات الكلية في منتج الكعك قد بلغت 74.92 ملغم/100غم و78.89ملغم/100غم و83.39 ملغم/100غم و88.85 ملغم/100غم للعينات ($T_0$، $T_1$، $T_2$، $T_3$) على التوالي، بينما النسبة المئوية للنشاط الكابح للجذور الحرة في عينات الكعك المضاف لها تراكيز مختلفة من قشور الرمان بلغت في مجموعة السيطرة ($T_0$) 21.20% وفي المعاملات T1وT2 و T3(24.07 و25.18 و27.12) % على التوالي. وبينت نتائج التقييم الحسي لمنتج الكعك ، تفوق المعاملة T1 على بقية المعاملات في القبول العام للمنتج، وإظهرت النتائج عدم وجود فروق معنوية ($P\leq0.05$) في صفة الطعم بين المعاملات ($T_0$، $T_1$، $T_2$) وايضاً بين المعاملتين ($T_2$، $T_3$)، كما أظهرت النتائج عدم وجود فروق معنوية بين المعاملات ($T_0$، $T_1$) وبين المعاملات ($T_1$،$T_2$)، وبين المعاملات ($T_2$،$T_3$) في صفة اللون، في حين أظهرت النتائج عدم وجود فروق معنوية في معاملات $T_0$ و $T_1$ و $T_2$ و $T_3$ لصفة الهشاشة، كما أظهرت نتائج التقييم الحسي عدم وجود فروق معنوية ($P\leq0.05$) بين جميع المعاملات لصفتي القوام و التقبل العام.

**الكلمات المفتاحية:** قشور الرمان، النشاط المضاد للأكسدة، الفينولات الكلية، الكعك الصغير المحلى، الخصائص الكيميائية والفيزيائية