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ORIGINAL ARTICLE

# Utilization of watermelon rinds and sharlyn melon peels as a natural source of dietary fiber and antioxidants in cake

Hanan M.A. Al-Sayed [a,*], Abdelrahman R. Ahmed [b]

[a] *Food Sci. Dept., Fac. of Agric., Ain Shams Univerisity, Shoubra El-Kheima, Cairo, Egypt*
[b] *Home Economics Department, Fac. of Specific Education, Ain Shams University, Cairo, Egypt*

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Cake

**Abstract** The aim of this work was to evaluate some physical and chemical properties of watermelon rind and sharlyn melon peel powders and its utilization as partially, substituted of wheat flour at levels of 2.5%, 5.0% and 7.5% or fat at levels of 5.0%, 10% and 15% in cake making. Watermelon rinds had higher moisture, ash, fat, protein and carbohydrates 10.61%, 13.09%, 2.44%, 11.17% and 56.00%, respectively as compared to sharlyn melon peels. On the other hand, sharlyn melon peels had higher content crud fiber (29.59%) than in watermelon rinds (17.28%). The water absorption capacity (WAC) and oil absorption capacity (OAC) of sharlyn melon peels was higher than that of watermelon rinds being 7.7, 7.13 (g water/g) and 2.24, 1.65 (g oil/g), respectively. Watermelon rinds showed significantly greater free radical scavenging activity and β-carotene (39.7% and 96.44%), respectively compared to sharlyn melon peels. It contained different types of phenolic compounds, the most abundant one was 4-hydroxybenzoic acid (958.3 μg/g dw) followed by vanillin (851.8 μg/g dw), while the lowest phenolic compound was coumaric acid (8.8 μg/g dw). On the other hand four phenolic compounds were identified in sharlyn melon peels namely, 4-hydroxybenzoic acid, vanillin, chlorgenic acid, and coumaric acid. The incorporation of WMR and SMP powders in cakes batter at all the studied levels enhanced the volume and specific volume of the baked cakes to overcome, those of the control. These materials also retard staling of cakes and inhibition the lipids oxidation and free fatty acids formation during storage. It is revealed that, substitution of 5% flour and 10% fat with watermelon rinds and sharlyn melon peels produced acceptable cakes which were not significantly different with the control.


* Corresponding author. Tel.: +20 1001864813; fax: +20 1061990654.
E-mail address: hananmohabdo@yahoo.com (H.M.A. Al-Sayed).
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## Introduction

Recently, it has taken a boom the use of fruit and vegetable waste to reduce environmental pollution. Taking into account that these residues are important sources of polyphenols. Agricultural and industrial residues are attractive sources of natural antioxidants and dietary fiber (Hemaida, 1994; Larrosa et al., 2002). In Egypt, there are many sources of fruit wastes

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but there is lake of information about their content and activity of antioxidant compounds.

Nawal et al. (2008) investigate the extraction and identification of antioxidant compounds in some vegetable and fruit wastes. New by-products applications should be investigated to have a positive environmental impact or to turn them into useful products. Accordingly, the functional properties of some peel components such as, pectin, flavonoids, carotenoids, limonene and polymethoxy flavones should be considered (Li et al., 2007).

Bakery products are widely consumed and are becoming a major component of the international food market (Kotsianis et al., 2002). Cake is one of the most common bakery products consumed by people in the world. Nowadays, cake manufacturers face a major problem of lipid oxidation which limits the shelf life of their products (Lean and Mohamed, 1999). Bakery products such as cakes particularly those with high lipid content tend to become rancid after prolonged storage owing to the oxidation of polyunsaturated fatty acids (Ray and Husain, 2002; Smith et al., 2004). Special attention has given to the use of natural antioxidant because of the world wide trend to avoid or minimize synthetic food additives (Kings and Berger, 2001).

In the recent years, an upward trend in bakery products with increased nutritional value, such as fiber-enriched suggests that products, has been observed. In order to increase the fiber content in cakes and muffins, several raw materials such as bran and outer layers of cereals (Polizzoto et al., 1983; Hudson et al., 1992), legume outer layer (Kaack and Pedersen, 2005), and processing by-products of apple (Sudha et al., 2007; Rupasinghe et al., 2008) have been used.

The quality of cake depends on the quantity and quality of ingredient especially the flour used in preparation. It was found that mixing two or more of different materials will help to solve the deficiency problem of cereal as low nutritional value (Patel and Rao, 1995).

As health promoting substances, phytochemical and non-nutritive substances can be considered functional in foods. These may be lignans, isoflavones, saponin and phytates, which can be found naturally in soy bean, flaxseed, some fruits and vegetables (Conforti and Davis, 2006).

The health-conscious public demands high-quality and low-calorie products that are low in fat and sugar. However, altering amount of ingredient to reduce caloric content may compromise texture, mouthfeel, flavor and appearance (Pong et al., 1991; Khalil, 1998).

Watermelon *Citrullus lanatus* (Thunb.), from the family of cucumber (*Cucurbitacea*), is a large, oval, round or oblong tropical fruit (Koocheki et al., 2007). The skin is smooth, with dark green rind or sometimes pale green stripes that turn yellowish green when ripe. It is a very rich source of vitamins and also serves as a good source of phytochemicals (Perkins-Veazie and Collins, 2004). The therapeutic effect of watermelon has been reported and has been ascribed to antioxidant compounds (Leong and Shui, 2002; Lewinsohn et al., 2005). The citrulline in watermelon rinds gives it antioxidant effects that protect you from free-radical damage. Additionally, citrulline converts to arginine, an amino acid vital to the heart, circulatory system and immune system. These researchers speculate that watermelon rind might relax blood vessels as cancer and cardiovascular diseases (Rimando and Perkins-Veazie, 2005). The rind is usually discarded; they are edible, and sometimes used as a vegetable.

Melons in genus *Cucumis* are culinary fruits, and include the majority of culinary melons. All but a handful of culinary melon varieties belong to the species. Sharlyn melons this melon tastes like a cantaloupe and honeydew combined. It is sweet with a netted outer layer, greenish-orange rind, and white flesh, and may be substituted for Crenshaw melons. Pair with lemons, yogurt, honey, chilies, sheep's milk cheese and vanilla. Serve in salads, cold soups and beverages (Mabberley, 1987).

The aim of this work was to evaluate some physical and chemical properties of watermelon rind and sharlyn melon peel powders and its utilization partially, substituted of wheat flour at levels of 2.5%, 5.0% and 7.5% or fat at levels of 5.0%, 10% and 15% as a natural source of dietary fiber and antioxidants in cake making.

## Materials and methods

### *Materials*

#### *Raw materials*

Fruits used in this study were obtained from local market in Cairo, Egypt. Waste materials used were namely watermelon (*C. lanatus)* rinds(WMR) and sharlyn melon (*Cucumis melo)* peels (SMP).

#### *Cake ingredients*

Sucrose (commercial grade), fat (palm oil), fresh whole egg, baking powder (sodium bicarbonate and cream of tartar), dry milk powder and vanillia (pure vanillia) were purchased from local market. Soft wheat flour (72% extraction) was obtained from the Cairo south Company of milling (EL-Haram Milling).

#### *Chemicals*

Sodium bicarbonate, sodium chloride, chloroform, Tween 20 were obtained from El-Gomhoreya Co., Cairo, Egypt. 1,1-Diphenyl-2-picryIhydrazyl radical (DPPH) β-carotene, butylated hydroxyl anisole (BHA) were purchased from Sigma–AL-drich Inc.(St. Louis, Mo, USA).

### *Methods*

#### *Preparation of water melon rind and sharlyn melon peel powders*

The watermelon rind and sharlyn melon peel were separated from the washed fresh fruits, cut into small pieces, spread in trays to rinse water, dried at 50 °C for 24 h using air oven, then ground in laboratory mill to fine powder.

#### *Processing of cake*

Cake samples were prepared according to the modified method of Bennion and Bamford (1973). The recipe of cake is summarized in Table 1 expressing the different ratios of watermelon rind and sharlyn melon peel powders used in this study. To prepare the control cake the sugar and shortening were creamed for 3 min. The whole eggs were added and mixed for 2 min. The sifted flour, baking powder and dry milk were added and the batter was mixed for 4 min. After scraping down the bowl the batter was mixed for an additional 1 min.

**Table 1** Recipe of cake.

| Ingredients | Flour | Sugar | Shortening | Fresh whole egg | Dry milk powder | Baking powder | Vanillin |
|---|---|---|---|---|---|---|---|
| g | 100 | 60 | 50 | 85 | 3 | 4 | 0.6 |

To prepare the substituted cakes batters, the flour in the formula was substituted with watermelon rinds or sharlyn melon peels the ratios of at 2.5%, 5% and 7.5%. In other treatment, shortening in the formula was substituted with water melon rinds or sharlyn melon peels 5%, 10% and 15%. The same order of mixing as described for the control was followed. Cakes batters were placed in each pan and baked in oven at 180 °C for 30 min. After baking, cakes were removed from pans and cooled at room temperature then packed in polyethylene bags and stored at room temperature for 21 days. Samples were taken after removal from pans within 1 h and often 1 week intervals for analysis.

*Analytical methods*

*Proximate analysis*. Moisture, ash, protein, fat and crude fiber of watermelon rind and sharlyn melon peel powder were determined according to the methods described in AOAC (1995). The carbohydrate was determined by difference.

*Water and oil absorption capacities*. Water absorption capacity (WAC) and oil absorption capacity (OAC) of watermelon rind, sharlyn melon peel powder were determined according to (Larrauri et al., 1996).

*Antioxidant activity. Free radical scavenging activity (DPPH test)*. Free radical scavenging activity {1,1-diphenyl-2-picryIhydrazyl radical (DPPH) test} of watermelon rind and sharlyn melon peel powder was determined according to The DPPH method of Lee et al. (2003).

*β-Carotene/linoleic acid bleaching*. The ability of watermelon rind, sharlyn melon peel powder and synthetic antioxidants (BHA) to prevent the bleaching of β-carotene was assessed as described by Keyvan et al. (2007).

*Identification of some phenolic compounds*. A total of 20 mg dried watermelon rinds and sharlyn melon peels powder samples were extracted for 15 min using 750 μL 70% methanol (v/v, pH 4, phosphoric acid) in an ultrasonic water bath (Sonorex digital 10p, Bandelin) on ice. Samples were centrifuged for 5 min at 6000 rpm. The supernatants were collected and the pellets were re-extracted twice more with 500 μL 70% methanol. The combined supernatants from each sample were reduced to near dryness in a centrifugation evaporator (Speed Vac, SC 110) at 25 °C. Samples were then made up to 1 ml with 40% acetonitrile. The samples were filtrated using 0.22 μm filter, and then analyzed with HPLC (Dionex Summit P680A HPLC-System) of Methods at laboratory of Food Biotechnology Department, Institute of Food Technology and Food Chemistry, Faculty of Process Sciences, Technical University of Berlin (Riedel et al., 2012).

*Determination of weight, volume and specific volume of cake samples*. The weight, volume (was measured by rapeseed displacement) and specific volume of cake samples were measured after 1 h of baking (Randez-Gil et al., 1995). The ratio of volume to weight was also calculated to obtain the specific volume.

*Determination of staling in cake samples*. Staling of baked cake containing watermelon rind and sharlyn melon peel powders was measured by alkaline water retention capacity (AWRC) according to Mohmoud and Abou-Arab (1989).

*Determination of color of cake samples*. The color and crumb of cake containing watermelon rind and sharlyn melon peel powders was determined according to the tristimulus color system described by Francis (1983) using spectrophotometer (MOM, 100D, and Hungary). Color coordinates $X$, $Y$ and $Z$ were converted to corresponding Hunter $L^*$, $a^*$ and $b^*$ color coordinates according to formula given by manufacturer. The chroma ($C$) represents color saturation or purity was calculated from $C = (a^2 + b^2)$ and total color intensity $= (a^2 + b^2 + L^2)^{1/2}$.

*Acid and peroxide value of cake lipids*. The lipids of cake were extracted using hexane as a solvent. The acid and peroxide values were determined according to AOAC (2000).

*Sensory evaluation of cake samples*. Ten panelists from the staff members of Food Science Department, Faculty of Agriculture, Ain Shams University were asked to score the quality attributes of each cake sample. Appearance, crust color, crumb color, crumb texture, taste, odor and overall acceptability were judged on a scale of 10 according to AACC (1996).

*Statistical analysis*. The experimental data were analyzed using analysis of variance and Duncan' multplirange at ($p \leqslant 0.05$). The data were analyzed according to User' Guide of Statistical Analysis System at computing Center of Faculty of Agriculture, Ain Shams University (SAS, 2004).

## Results and discussion

*Some physical and chemical properties of watermelon rind and sharlyn melon peel powders*

*Proximate composition WAC, OAC and antioxidant activity of watermelon rind and sharlyn melon peel powders*

Data in Table 2 showed that the watermelon rind powder had higher moisture, ash, fat, protein and carbohydrates (10.61%, 13.09%, 2.44%, 11.17% and 56.02%, respectively) as compared to sharlyn melon peel powder. On the other hand, the sharlyn melon peels had higher content of crud fiber (29.59%) as compared to watermelon rinds (17.28%). The crud fiber content in watermelon rind and sharlyn melon peel powder was higher than navel orange peels (13.38%) and mandarin peels (7.14%) as mentioned by Magda et al. (2008). It means that the utilization of watermelon rind and sharlyn melon peel powder in some bakery products increase their contents of fiber.

**Table 2** Proximate composition, WAC, OAC and antioxidant activity of watermelon rind and sharlyn melon peel powders (% of wet basis).

| Characteristics | Watermelon rinds | Sharlyn melon peels |
|---|---|---|
| Moisture (%) | 10.61[a] | 6.49[b] |
| Ash (%) | 13.09[a] | 11.09[b] |
| Fat (%) | 2.44[a] | 1.58[b] |
| Protein (%) | 11.17[a] | 9.07[b] |
| Crude fiber (%) | 17.28[b] | 29.59[a] |
| Carbohydrates* (%) | 56.02[a] | 48.67[b] |
| WAC (g $H_2O$/g) | 7.13[b] | 7.7[a] |
| OAC (g oil/g) | 1.65[b] | 2.24[a] |
| DPPH (%) | 39.7[a] | 12.53[b] |
| B-Carotene (%) | 9.6.44[a] | 76.80[b] |

Means values in the same row showed the same superscript small letter are not significantly different ($p \geqslant 0.05$).
* Total carbohydrate was calculated by difference.

The water absorption capacity (WAC) and oil absorption capacity (OAC) of sharlyn melon peels were higher than those of watermelon rinds being 7.7and 7.13 (g water/g) and 2.24 and 1.65 (g oil/g), respectively, indicating that the higher crude fiber in sharlyn melon peels hold more water and oil compared to watermelon rinds. While, watermelon rinds significantly greater free radical scavenging activity expressed as DPPH% and β-carotene (39.7% and 96.44%, respectively) compared to sharlyn melon peels. It could be observed that the watermelon rinds is more effective as an antioxidant than sharlyn melon peels. These data are in agreement with that obtained by Matook and Hashinaga (2005) and Magda et al. (2008).

### *Identification of phenolic compounds*

The amount of phenolic compounds is an important factor when evaluating the quality of different extracts, it involved for their resistance to oxidation and the properties attributed to these antioxidant (Moure et al., 2001). As shown in Table 3 the watermelon rinds contained different types of phenolic compounds, the most abundant one was 4-hydroxybenzoic acid (958.3 μg/g dw) followed by vanillin (851,8 μg/g dw), while the lowest phenolic compounds was coumaric acid 8.8(μg/g dw). On the other hand four phenolic compounds were identified in sharlyn melon peels namely, 4-hydroxybenzoic acid, vanillin, chlorgenic acid, and coumaric acid with amounts ranged from 66.2 to 325.3 μg/g dw. It was clearly noticed that the content of these phenolics was much higher in watermelon rinds than sharlyn melon peels except the coumarie acid.

**Table 3** Identification of phenolic extracts of watermelon rind and sharlyn melon peel powders.

| Phenolic compounds (μg/g dw) | Methanolic extract | |
|---|---|---|
| | Watermelon rinds | Sharlyn melon peels |
| 4-Hydroxybenzoic acid | 958.3 | 325.3 |
| Vanillin | 851.8 | 199.2 |
| Chlorogenic acid | 196.3 | 66.2 |
| Caffeic acid | 41.4 | – |
| Syringic acid | 32.3 | – |
| Coumaric acid | 8.8 | 80.8 |
| Sinapinic acid | 137.6 | – |
| P-anisic acid | 81.5 | – |
| Hydroxycinnamic acid | 46.5 | – |
| Cinnamic acid | 35.5 | – |

### *Utilization of watermelon rind and sharlyn melon peel powders as substitution of flour in cake*

### *Proximate composition of cake samples*

From Table 4 it could be noticed that the fat content of cake samples were not significantly affected by substituting the flour with watermelon rind and sharlyn melon peel powder. Meanwhile, a gradual decrease in protein and moisture content of cake samples containing watermelon rind and sharlyn melon peel powder was observed with raising the replacement level. It could be also noticed that the utilization of watermelon rind and sharlyn melon peel powder in cakes resulted in grdual increase in its content of carbohydrates and ash with increasing the level of substitution. The decrease in protein and moisture content in utilized cakes were due to their lower content in watermelon rind and sharlyn melon peel powder than in flour, while the increased in ash and carbohydrate content were due to their higher content in the used substituted materials than in flour as shown in Table 2. These results are agreement with (Hanaa and Eman, 2010).

### *Weight, volume and specific volume of cake samples*

Weight, volume and specific volume of cakes containing substituted flour with different levels of watermelon rind and sharlyn melon peel powder are given in Table 5. The utilization of watermelon rind and sharlyn melon peel powder in cakes resulted in an increase in their weight more than of the control one, except, cake samples substituted with 5.0%and 7.5% sharlyn melon peel powder, they were lesser in their weight. It was noticed that the incorporation of watermelon rind and sharlyn melon peel powder in cake batter at all the studied levels enhanced the volume of the baked cakes to overcome those of the control, especially at the level of 0.5% of watermelon

**Table 4** Proximate analysis of cake containing substituted flour with different levels of watermelon rind and sharlyn melon peel powders.

| Substitution (%) | Moisture (%) | Fat (%) | Ash (%) | Protein (%) | Total carbohydrates* |
|---|---|---|---|---|---|
| Control (zero) | 27.04[a] | 13.40[a] | 1.48[e] | 9.49[a] | 48.58[c] |
| *Watermelon rinds* | | | | | |
| 2.5 | 24.17[bcd] | 13.39[a] | 1.78[c] | 8.88[b] | 51.76[b] |
| 5.0 | 23.26[d] | 13.39[a] | 1.94[b] | 8.55[b] | 52.84[a] |
| 7.5 | 25.24[b] | 13.49[a] | 2.11[a] | 7.50[c] | 51.64[b] |
| *Sharlyn melon peels* | | | | | |
| 2.5 | 24.62[bc] | 13.40[a] | 1.70[d] | 9.28[a] | 50.99[b] |
| 5.0 | 25.13[b] | 13.34[a] | 1.83[c] | 8.63[b] | 51.05[b] |
| 7.5 | 23.79[cd] | 13.41[a] | 2.04[a] | 7.74[c] | 53.00[a] |

Means values in the same column showed the same superscript small letter are not significantly different ($p \geqslant 0.05$).
* Total carbohydrate was calculated by difference.

**Table 5** Weight, volume and specific volume of cake containing substituted flour with different levels of watermelon rind and sharlyn melon peel powders.

| Substitution (%) | Weight (g) | Volume ($cm^3$) | Specific volume ($cm^3$/g) |
|---|---|---|---|
| Control (zero) | 164.44$^{c}$ | 311.67$^{e}$ | 1.89$^{d}$ |
| *Watermelon rinds* | | | |
| 2.5 | 164.23$^{c}$ | 385.00$^{b}$ | 2.34$^{b}$ |
| 5.0 | 157.13$^{a}$ | 403.33$^{a}$ | 2.56$^{a}$ |
| 7.5 | 168.68$^{d}$ | 340.00$^{d}$ | 2.013$^{c}$ |
| *Sharlyn melon peels* | | | |
| 2.5 | 174.63$^{e}$ | 321.67$^{e}$ | 1.84$^{d}$ |
| 5.0 | 174.35$^{e}$ | 351.67$^{c}$ | 2.01$^{c}$ |
| 7.5 | 160.53$^{b}$ | 318.33$^{e}$ | 1.98$^{c}$ |

Means values in the same column showed the same superscript small letter are not significantly different ($p \geqslant 0.05$).

rind, their values were 403.33 $cm^3$ and 2.56 $cm^3$ g compared to 311.67 $cm^3$ and 1.89 $cm^3$/g only of the control cake, respectively. On exception was noticed when the sharlyn melon peel powder was used at 2.5% the volume and specific volume of cake were statistically equal to those of the control, in addition when it was used at 7.5% the produced cake had significantly the same volume compared to control. These results are agreement with Singh et al. (1995) who, reported that cake volume and specific volume significantly increased with increased level of type of fiber.

### *Hunter-lab color values of cake samples*

All color data are expressed as Hunter $L^*$, $a^*$, and $b^*$ values corresponding to lightness, redness, and yellowness, respectively. Hunter-lab color values of cake contained substituted flour at different levels of watermelon rind and sharlyn melon peel powder are given in Table 6. Crust and crumb color of cakes varied with the quantity and the kind of the supplemented materials the crust became lighter (higher $L^*$) as the watermelon rind and sharlyn melon peel powders level increased compared to that of control cake. No considerable differences in crust yellowness were found among the different watermelon rinds samples, while sharlyn melon peels samples exhibited higher $b^*$ values than the respective watermelon rinds samples, both gave higher $b^*$ values than the control cake sample.

Concerning crumb color, in generally, as watermelon rinds powder level increased $L^*$ and $b^*$ values decreased while $a^*$ value increased and the crumb color became darker and more greenish. However as the level of sharlyn melon peels powder increased $L^*$ and $a^*$ values decreased, while $b^*$ value showed an increasing trend, indicating that a darker, more then less redder, and more yellowness crumb. The crumb of the control cake was lighter and more yellow compared to the tested cakes. It was well known that during cake baking, the crumb, dose not reach a degree crumb does not reach adgree above 100 °C, so the Millard or caramelization reactions fail to take place. Therefore, the resulted of crumb color of tested cake was due to the color of the used substituted materials and their interactions. Im and Kim (1999) also reported that, the addi-

**Table 6** Hunter-lab color values of cake containing substituted flour with different levels of watermelon rind and sharlyn melon powders.

| Substitution (%) | Crust | | | | | Crumb | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $L^*$ | $a^*$ | $b^*$ | Chroma | Total intensity | $L^*$ | $a^*$ | $b^*$ | Chroma | Total intensity |
| Control (zero) | 44.48$^{f}$ | 14.44$^{a}$ | 26.83$^{f}$ | 30.47$^{d}$ | 53.92$^{f}$ | 76.12$^{a}$ | 7.69$^{d}$ | 28.18$^{d}$ | 29.21$^{d}$ | 81.54$^{a}$ |
| *Watermelon rinds* | | | | | | | | | | |
| 2.5 | 49.08$^{e}$ | 11.36$^{d}$ | 27.73$^{e}$ | 29.97$^{e}$ | 57.51$^{e}$ | 73.32$^{b}$ | 8.29$^{c}$ | 26.14$^{f}$ | 27.42$^{g}$ | 78.28$^{b}$ |
| 5.0 | 43.17$^{g}$ | 11.85$^{c}$ | 24.72$^{g}$ | 27.42$^{f}$ | 51.13$^{g}$ | 70.71$^{d}$ | 9.87$^{a}$ | 26.10$^{f}$ | 27.90$^{f}$ | 76.01$^{e}$ |
| 7.5 | 56.31$^{a}$ | 12.75$^{b}$ | 29.31$^{c}$ | 31.97$^{c}$ | 64.75$^{b}$ | 67.54$^{g}$ | 9.01$^{b}$ | 27.24$^{e}$ | 28.70$^{e}$ | 73.38$^{g}$ |
| *Sharlyn melon peels* | | | | | | | | | | |
| 2.5 | 50.71$^{c}$ | 11.39$^{d}$ | 33.52$^{b}$ | 35.40$^{b}$ | 61.85$^{c}$ | 72.08$^{c}$ | 8.28$^{c}$ | 26.55$^{e}$ | 29.73$^{b}$ | 77.98$^{c}$ |
| 5.0 | 54.17$^{b}$ | 8.81$^{e}$ | 35.81$^{a}$ | 36.88$^{a}$ | 65.53$^{a}$ | 68.31$^{f}$ | 5.08$^{f}$ | 31.53$^{a}$ | 31.94$^{a}$ | 75.40$^{f}$ |
| 7.5 | 49.27$^{d}$ | 11.52$^{d}$ | 28.21$^{d}$ | 30.48$^{d}$ | 57.93$^{d}$ | 70.64$^{e}$ | 5.76$^{e}$ | 28.82$^{b}$ | 29.39$^{c}$ | 76.35$^{d}$ |

Means values in the same column showed the same superscript small letter are not significantly different ($p \geqslant 0.05$).

**Table 7** Moisture content of cake containing substituted flour with different levels of watermelon rind and sharlyn melon peel powders during storage at room temperature for 21 days.

| Storage period (days) | Control (zero) | Watermelon rinds (%) | | | Sharlyn melon peels (%) | | |
|---|---|---|---|---|---|---|---|
| | | 2.5 | 5.0 | 7.5 | 2.5 | 5.0 | 7.5 |
| Zero | 27.09$^{Aa}$ | 24.26$^{Ca}$ | 23.23$^{Da}$ | 26.71$^{Aa}$ | 24.70$^{BCa}$ | 25.21$^{Aa}$ | 25.02$^{Ba}$ |
| 7 | 25.25$^{Bb}$ | 23.15$^{Db}$ | 23.03$^{Da}$ | 26.37$^{Aab}$ | 24.58$^{BCa}$ | 24.85B$^{Ca}$ | 24.39$^{Cab}$ |
| 14 | 22.55$^{Dc}$ | 22.52$^{Dc}$ | 23.16$^{CDa}$ | 25.86$^{Abc}$ | 24.53$^{Ba}$ | 24.53$^{Ba}$ | 23.95$^{BCbc}$ |
| 21 | 21.64$^{Dc}$ | 21.99$^{Dd}$ | 22.46$^{Da}$ | 25.60$^{Ac}$ | 24.45$^{Ba}$ | 24.22$^{BCa}$ | 23.44$^{Cc}$ |

Means values in the same column showed the same superscript small letter are not significantly different ($p \geqslant 0.05$) Means values in the same row showed the same superscript capital letter are not significantly different ($p \geqslant 0.05$).

**Table 8** Staling of cake containing substituted flour with different levels of watermelon rind and sharlyn melon peel powders during storage at room temperature for 21 days.

| Storage period (days) | Control (zero) | Watermelon rinds (%) | | | Sharlyn melon peels (%) | | |
|---|---|---|---|---|---|---|---|
| | | 2.5 | 5.0 | 7.5 | 2.5 | 5.0 | 7.5 |
| Zero | $379.39^{Fa}$ | $461.89^{Aa}$ | $394.42^{Ea}$ | $413.51^{Da}$ | $423.60^{Ca}$ | $437.15^{Bb}$ | $424.76^{Ca}$ |
| 7 | $327.24^{Fb}$ | $412.10^{Bb}$ | $394.42^{Da}$ | $374.74^{Eb}$ | $371.61^{Eb}$ | $486.66^{Aa}$ | $404.08^{Cb}$ |
| 14 | $316.49^{Ec}$ | $352.86^{Ac}$ | $336.76^{Db}$ | $316.57^{Ec}$ | $338.81^{Cc}$ | $347.44^{Bc}$ | $336.76^{Cc}$ |
| 21 | $286.56^{Gd}$ | $320.86^{Bd}$ | $327.77^{Ad}$ | $314.06^{Ed}$ | $307.40^{Fd}$ | $314.70^{Dd}$ | $316.62^{Cd}$ |

Means values in the same column showed the same superscript small letter are not significantly different ($p \geqslant 0.05$) Means values in the same row showed the same superscript capital letter are not significantly different ($p \geqslant 0.05$).

tion of green tea powder affected the crumb color and caused $L^*$ and $b^*$ values to decrease.

*Moisture content of cake samples during storage*

From Table 7, the moisture content of cake containing substituted flour with watermelon rind or sharlyn melon peel powders at level of 2.5%, 5.0% and 7.5% ranged between 23.23% and 27.09% at zero time. During storage, the moisture content of all cake samples gradually decreased, it reached a values ranging between 21.64 for control sample to 25.60% in cake containing substituted flour with 7.5% watermelon rinds powder after 21 days. The highest losses in moisture content of cake samples were observed for control cake sample followed by cake of substituted flour with 2.5% watermelon rind powder. While, other tested cakes retained most of the moisture, its content was practically the same at every storage period till the end of strong. This finding was due to the higher WAC of the used substituted material s, especially sharlyn melon peel powders as shown in Table 2.

*Staling of cake samples during storage*

Changes in staling of cake samples were followed during 21 days of storage and the results are shown in Table 8. The staling values of different cake samples were reduced gradually during storage. The lower reduction in these values (high freshness) was achieved in cake containing substituted flour with different levels of watermelon rind powder and control cake sample. Results showed that substituting of 2.5% and 5% flour by watermelon rinds recorded the highest values staling being 320.86% and 327.77%, respectively, followed by substituting with 7.5% sharlyn melon peel powder (316.62%) after 21 days of storage compared to control sample (286.56%).

*Peroxide and acid values of cake samples during storage*

The changes in peroxide value (PV) and acid value (AV) of lipid extracted from cake made from substituted flour with watermelon rind and sharlyn melon peel powders during storage are given in Figs. 1 and 2. An increase in PV and AV were observed in all the cake samples on storage. The increases were considerably higher in control cake sample compared to other samples in which synthetic BHA or natural antioxidants were incorporated. A gradual increase (up to 1.62) were observed indicating the potency of antioxidant of watermelon rinds and sharlyn melon peels in inhibiting lipids oxidation and hydrolysis and the formation of peroxides and free fatty acid. In general, all the used substitution level slowed down the rate of peroxide formation and fatty acid being more effective. All samples and contained BHA were lower than that of control samples during storage. The PV and AV of lipids extracted from the control cake sample after baking did not differ considerably from the corresponding value of other samples. The PV and AV of all the treated cake samples decreased as

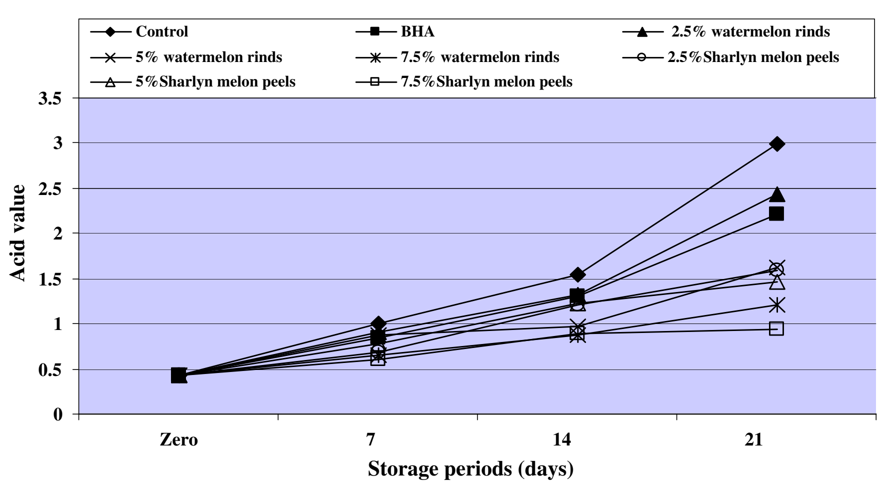


**Fig. 1** Acid value of cake containing substituted flour with different levels of watermelon rind and sharlyn melon peel powders during storage at room temperature for 21 days.

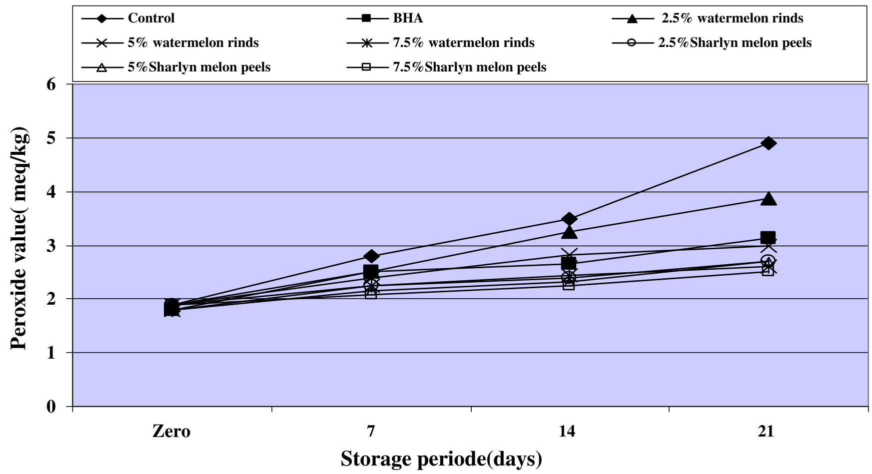


**Fig. 2** Peroxide values of cake containing substituted flour with different levels of watermelon rind and sharlyn melon peel powders during storage at room temperature for 21 days.

**Table 9** Statistical analysis of scores of sensory properties of cake containing substituted flour with different levels of watermelon rind and sharlyn melon peel powders during storage at room temperature for 21 days.

| Storage period (days) | Control | Watermelon rinds (%) | | | Sharlyn melon peels (%) | | |
|---|---|---|---|---|---|---|---|
| | | 2.5 | 5 | 7.5 | 2.5 | 5 | 7.5 |
| *Appearance* | | | | | | | |
| Zero | $8.60^{Aa}$ | $8.40^{ABa}$ | $8.60^{Aa}$ | $7.60^{Ba}$ | $8.80^{Aa}$ | $8.00^{ABab}$ | $7.60^{Ba}$ |
| 7 | $7.20^{Bb}$ | $7.40^{ABb}$ | $7.60^{ABb}$ | $7.20^{Ba}$ | $8.40^{Aab}$ | $8.20^{ABa}$ | $7.60^{ABa}$ |
| 14 | $7.80^{ABab}$ | $8.00^{Aab}$ | $8.00^{Aab}$ | $7.20^{Ba}$ | $7.80^{ABbc}$ | $8.00^{Aab}$ | $7.20^{Bab}$ |
| 21 | $7.40^{Ab}$ | $7.80^{Aab}$ | $7.40^{Ab}$ | $6.60^{Ba}$ | $7.40^{Ac}$ | $7.20^{ABc}$ | $6.60^{Bb}$ |
| *Crust color* | | | | | | | |
| Zero | $8.20^{ABa}$ | $8.20^{ABa}$ | $8.0^{ABCa}$ | $7.00^{Ca}$ | $8.80^{Aa}$ | $8.20^{ABa}$ | $7.60^{BCa}$ |
| 7 | $8.00^{Aa}$ | $7.60^{ABab}$ | $7.80^{ABa}$ | $7.00^{Ba}$ | $8.20^{Aab}$ | $8.00^{Aa}$ | $7.40^{ABa}$ |
| 14 | $8.00^{Aa}$ | $8.00^{Aab}$ | $7.80^{Aa}$ | $7.00^{Ba}$ | $8.20^{Aab}$ | $7.80^{Aab}$ | $7.00^{Ba}$ |
| 21 | $7.80^{Aa}$ | $7.40^{ABb}$ | $7.40^{ABa}$ | $6.80^{Ba}$ | $7.40^{ABc}$ | $7.00^{Bc}$ | $5.60^{Cb}$ |
| *Crumb color* | | | | | | | |
| Zero | $8.40^{Aa}$ | $8.00^{ABa}$ | $8.20^{Aa}$ | $7.00^{Ba}$ | $8.60^{Aa}$ | $8.0^{ABa}$ | $7.80^{ABa}$ |
| 7 | $7.80^{ABab}$ | $7.40^{ABa}$ | $7.20^{Bb}$ | $7.00^{Ba}$ | $8.20^{Aab}$ | $7.60^{ABab}$ | $7.20^{Ba}$ |
| 14 | $8.00^{Aab}$ | $7.60^{Ba}$ | $7.60^{Bab}$ | $6.80^{Ba}$ | $7.60^{Bab}$ | $7.80^{Bab}$ | $7.40^{ABa}$ |
| 21 | $7.60^{Ab}$ | $7.20^{ABa}$ | $7.20^{ABb}$ | $6.60^{BCa}$ | $7.40^{ABc}$ | $6.80^{ABCc}$ | $6.00^{Cb}$ |
| *Crumb texture* | | | | | | | |
| Zero | $8.60^{ABa}$ | $8.60^{ABa}$ | $8.60^{ABa}$ | $8.00^{ABa}$ | $8.00^{Aa}$ | $7.80^{ABa}$ | $7.60^{Ba}$ |
| 7 | $7.60^{ABb}$ | $8.00^{Ab}$ | $7.80^{ABb}$ | $7.20^{Bb}$ | $8.00^{Ab}$ | $8.00^{Aa}$ | $7.40^{ABa}$ |
| 14 | $7.60^{ABb}$ | $7.80^{ABb}$ | $7.60^{ABb}$ | $6.80^{Cb}$ | $8.00^{Ab}$ | $7.80^{ABa}$ | $7.00^{BCab}$ |
| 21 | $7.40^{ABCb}$ | $7.40^{ABb}$ | $7.60^{Ab}$ | $6.00^{Dc}$ | $6.80^{BCc}$ | $6.80^{BCa}$ | $6.40^{CDb}$ |
| *Taste* | | | | | | | |
| Zero | $8.40^{ABa}$ | $8.40^{ABa}$ | $8.40^{ABa}$ | $7.80^{Ba}$ | $8.60^{Aa}$ | $8.40^{ABa}$ | $8.00^{ABa}$ |
| 7 | $8.00^{ABa}$ | $8.00^{ABab}$ | $7.60^{BCa}$ | $7.60^{BCa}$ | $8.60^{Aa}$ | $7.40^{BCb}$ | $7.00^{Cb}$ |
| 14 | $7.00^{BCb}$ | $7.80^{ABb}$ | $7.8^{ABa}$ | $7.00^{BCa}$ | $8.00^{Aa}$ | $7.2^{ABCb}$ | $6.60^{Cc}$ |
| 21 | $6.80^{Bb}$ | $7.20^{ABc}$ | $7.60^{Aa}$ | $5.40^{Cb}$ | $7.00^{ABb}$ | 6.80Bb | $5.80^{Cd}$ |
| *Odor* | | | | | | | |
| Zero | $8.00^{BCa}$ | $8.60^{ABa}$ | $8.80^{Aa}$ | $7.60^{Ca}$ | $8.60^{ABa}$ | $8.00^{BCa}$ | $8.20^{ABCa}$ |
| 7 | $7.00^{Bb}$ | $7.60^{ABbc}$ | $7.60^{ABb}$ | $7.00^{Ba}$ | $8.40^{Aa}$ | $7.40^{ABa}$ | $7.20^{Bb}$ |
| 14 | $6.60^{Cbc}$ | $8.20^{Aab}$ | $7.40^{BCb}$ | $7.00^{BCa}$ | $7.80^{ABab}$ | $7.20^{BCab}$ | $5.80^{Dc}$ |
| 21 | $6.20^{Bc}$ | $7.20^{Ac}$ | $7.00^{Ab}$ | $5.80^{Bb}$ | $7.20^{Ac}$ | $6.40^{Bc}$ | $5.80^{Bc}$ |
| *Overall acceptability* | | | | | | | |
| Zero | $8.20^{ABa}$ | $8.20^{ABa}$ | $8.60^{Aa}$ | $7.60^{Ba}$ | $8.80^{Aa}$ | $8.20^{ABa}$ | $7.80^{Ba}$ |
| 7 | $8.00^{ABCa}$ | $8.40^{ABa}$ | $7.80^{BCb}$ | $7.40^{Cab}$ | $8.60^{Aa}$ | $7.80^{BCab}$ | $7.40^{Ca}$ |
| 14 | $7.40^{BCa}$ | $8.20^{Aa}$ | $7.60^{ABCb}$ | $7.00^{Db}$ | $8.00^{ABab}$ | $7.80^{ABab}$ | $6.40^{Db}$ |
| 21 | $6.60^{BCDb}$ | $7.40^{Ab}$ | $7.00^{ABCc}$ | $6.00^{Dc}$ | $7.40^{Ac}$ | $7.20^{ABb}$ | $6.40^{CDb}$ |

Means values in the same column showed the same superscript small letter are not significantly different ($p \geqslant 0.05$).
Means values in the same row showed the same superscript capital letter are not significantly different ($p \geqslant 0.05$).

the level of watermelon rind and sharlyn melon peel powders increased. These results are in agreement with those of Vanitha et al. (2005).

### *Sensory evaluation of cake samples during storage*

Sensory evaluation of cakes containing substituted flour at different levels of watermelon rinds and sharlyn melon peels during storage at room temperature for 21 days are listed in Table 9. The sensory scores of cake containing substituted flour at different levels of watermelon rinds and sharlyn melon peels powders were significantly affected.

As the level of these materials increased, the received score values significantly decreased in all their quality attributed. Cake samples made from substituted flour with 2.5% watermelon rinds or sharlyn melon peels showed no significant differences in all their sensory properties and were as acceptable as those of control cake sample. Storage of different cake samples for 21 days significantly reduced all their sensory properties. The minimum reduction in sensory properties was observed in cake substituted with flour at 2.5% watermelon rind or sharlyn melon peel powders followed by 5% of sharlyn melon peels then 5% of watermelon rinds while the maximum reduction was shows in control sample. These results revealed that 2.5% substitution of flour with watermelon rind and sharlyn melon peel powder produced an acceptable cake which was not significantly different from the control cake.

### *Utilization of watermelon rind and sharlyn melon peel powders as substitution of fat in cake*

### *Proximate composition of cake samples*

From Table 10, the moisture content of all the treated samples was lower than that of control without any significant differences between them. The watermelon rind and sharlyn melon peel powders were significantly affected the fat and ash content of cakes. However, the fat content of cake significantly decreased whereas the ash content showed a significant increasing as the level of substitution increased compared to the control. Concerning the protein content all the samples, it was not affected and had practically the same values. While the total carbohydrates were significantly increased in substituted cake compared to the control without any differences among the treatments.

### *Weight volume and specific volume of cake samples*

From Table 11. It was clearly noticed that with increasing the substituted level of watermelon rind or sharlyn melon peel powders as fat replaces in cake batter, the weight of baked cake increased being more than the control one, while the volume and specific volume decreased, but those of the control cake. The cake made from fat substituted with sharlyn melon peels powder at all levels were significant higher in their specific volume than of all other treatments than all treatments and control cake. The present finding is agreed with Chen et al. (1988) who reported that loaf volume and specific volumesignificantly are decreased with the increase in level of fiber.

### *Hunter-lab color values of cake samples*

As shown in Table 12, the crust color of cakes varied with the quantity and the kind of substitution (watermelon rinds or sharlyn melon peels). Generally, it became lighter (higher

**Table 11** Weight, volume and specific volume of cake containing substituted fat with different levels of watermelon rind and sharlyn melon peel powders.

| Substitution (%) | Weight (g) | Volume ($cm^3$) | Specific volume ($cm^3/g$) |
|---|---|---|---|
| Control (zero) | $164.44^{ab}$ | $311.67^{d}$ | $1.89^{de}$ |
| BHA (0.02%) | $169.97^{d}$ | $321.67^{c}$ | $1.89^{de}$ |
| *Watermelon rinds* | | | |
| 5 | $162.57^{a}$ | $326.67^{c}$ | $2.01^{c}$ |
| 10 | $166.75^{bc}$ | $326.67^{c}$ | $1.96^{cd}$ |
| 15 | $177.93^{e}$ | $330.00^{c}$ | $1.82^{e}$ |
| *Sharlyn melon peels* | | | |
| 5 | $166.13B^{c}$ | $385.00^{a}$ | $2.32^{a}$ |
| 10 | $167.89^{cd}$ | $355.00^{b}$ | $2.11^{b}$ |
| 15 | $176.82^{e}$ | $381.67^{a}$ | $2.16^{b}$ |

Means values in the same column showed the same superscript small letter are not significantly different ($p \geqslant 0.05$).

**Table 10** Proximate analysis of cake containing substituted fat with different levels of watermelon rind and sharlyn melon peel powders.

| Substitution (%) | Moisture (%) | Fat (%) | Ash (%) | Protein (%) | Total carbohydrates* |
|---|---|---|---|---|---|
| Control (zero) | $27.04^{a}$ | $13.40^{a}$ | $1.48^{e}$ | $9.49^{ab}$ | $48.58^{c}$ |
| BHA (0.02%) | $25.60^{ab}$ | $13.37^{a}$ | $1.56^{d}$ | $9.38^{ab}$ | $50.08^{bc}$ |
| *Watermelon rinds* | | | | | |
| 5 | $25.96^{ab}$ | $9.93^{b}$ | $1.82^{c}$ | $9.44^{ab}$ | $51.84^{ab}$ |
| 10 | $25.34^{b}$ | $8.86^{c}$ | $1.87^{bc}$ | $8.95^{b}$ | $52.97^{a}$ |
| 15 | $25.14^{b}$ | $6.65^{d}$ | $2.25^{a}$ | $10.02^{a}$ | $51.92^{ab}$ |
| *Sharlyn melon peels* | | | | | |
| 5 | $25.22^{b}$ | $10.19^{b}$ | $1.80^{c}$ | $8.79^{b}$ | $53.31^{a}$ |
| 10 | $25.76^{ab}$ | $9.14^{c}$ | $1.84^{c}$ | $9.17^{ab}$ | $52.42^{a}$ |
| 15 | $25.02^{b}$ | $7.86^{d}$ | $1.94^{b}$ | $9.17^{ab}$ | $53.12^{a}$ |

Means values in the same column showed the same superscript small letter are not significantly different ($p \geqslant 0.05$).
* Total carbohydrate was calculated by difference.

**Table 12** Hunter-lab color values of cake containing substituted fat with different levels of watermelon rind and sharlyn melon peel powders.

| Substitution (%) | Crust | | | | | Crumb | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $L^*$ | $a^*$ | $b^*$ | Chroma | Total intensity | $L^*$ | $a^*$ | $b^*$ | Chroma | Total intensity |
| Control (zero) | $44.48^{h}$ | $14.44^{a}$ | $26.83^{f}$ | $30.47^{h}$ | $53.92^{h}$ | $76.12^{a}$ | $7.69^{e}$ | $28.18^{c}$ | $29.21^{b}$ | $81.54^{a}$ |
| BHA (0.02%) | $50.84^{e}$ | $13.51^{b}$ | $35.37^{a}$ | $37.86^{a}$ | $63.98^{b}$ | $75.59^{b}$ | $9.22^{c}$ | $29.39^{a}$ | $30.81^{a}$ | $81.65^{a}$ |
| *Watermelon rinds* | | | | | | | | | | |
| 5 | $50.04^{f}$ | $10.59^{d}$ | $31.18^{d}$ | $32.94^{a}$ | $59.91^{f}$ | $74.37^{c}$ | $8.69^{d}$ | $26.42^{f}$ | $27.74^{f}$ | $79.37^{b}$ |
| 10 | $51.98^{c}$ | $9.38^{e}$ | $33.47^{b}$ | $34.76^{b}$ | $62.54^{d}$ | $72.78^{d}$ | $10.06^{b}$ | $25.91^{g}$ | $27.79^{f}$ | $77.91^{c}$ |
| 15 | $46.39^{g}$ | $10.25^{d}$ | $29.22^{e}$ | $30.97^{g}$ | $55.78^{g}$ | $70.35^{g}$ | $11.23^{a}$ | $26.42^{f}$ | $28.71^{d}$ | $75.78^{f}$ |
| *Sharlyn melon peels* | | | | | | | | | | |
| 5 | $52.73^{b}$ | $10.92^{cd}$ | $32.33^{c}$ | $34.13^{c}$ | $62.54^{c}$ | $71.19^{f}$ | $6.45^{g}$ | $28.03^{d}$ | $28.77^{cd}$ | $76.78^{e}$ |
| 10 | $51.58^{d}$ | $11.71^{c}$ | $29.53^{e}$ | $31.77^{f}$ | $60.58^{e}$ | $72.02^{e}$ | $6.90^{f}$ | $27.25^{e}$ | $28.12^{e}$ | $77.32^{d}$ |
| 15 | $55.52^{a}$ | $8.60^{e}$ | $32.24^{c}$ | $33.37^{d}$ | $74.78^{a}$ | $69.30^{h}$ | $4.60^{h}$ | $28.47^{b}$ | $28.84^{c}$ | $75.06^{g}$ |

Means values in the same column showed the same superscript small letter are not significantly different ($p \geqslant 0.05$).

$L^*$) and its $b^*$ values chroma, and total intensity values increased as the watermelon rinds or Sharlyn melon peels quantity increased compared to control values, while the $a^*$ value of the crust showed some increases and decreases, but all its values were lesser than of the control crust. All watermelon rinds or sharlyn melon peels gave higher $b^*$ values than the control cake sample. On the other hand, in (Table 12) the values of $L^*$ and $b^*$ and chroma of crmb decreased, while its total intensity increased with raising the watermelon rind or sharlyn melon peel powder compared to control crumb. In general, as watermelon rinds level increased, the crumb color became darker and more redness ($a^*$ value) and, while the incorporation of greenish, as measured by the colorimeter. sharlyn melon peels powder reduced the redness of crumb color compared to that of the control. There obtained results are in conformable with those of who indicated that In the case of adding a powder different from flour, browning is influenced by the type and color of the added powder (Shin et al., 2007).

### *Moisture content of cake samples during storage*

Table 13, showed that the moisture content of cake made from substitute fat with watermelon rind and sharlyn melon peel powder at the levels of 5%, 10% and 15% was practically the same at all the storage period and ranged between 24.12% and 25.89% compared to that of the control cake which begin from 27.09% at zero time It means that the used substituted materials at all the levels uphold the moisture content of cakes during storage. However, control cake had lowest moisture content among the studied treatments after 21 days of storage.

### *Staling of cake samples during storage*

Changes in staling of cake samples were followed during 21 days of storage and the results are summarized in Table 14. It was clearly noticed from the obtained data that the incorporation of either watermelon rind or sharlyn melon peel powder in cake batter as replaces of fat at all the studied levels enhanced the baked cakes freshness at all the storage period being significantly higher than the control at all the corresponding periods. The staling values of the different cake samples were reduced gradually during storage. The lower reduction in staling values (high freshness) was achieved in cake made from substituted fat with different levels of watermelon rinds and the control cake sample. It was observed that cake substituted with 5% sharlyn melon peels had the highest values of staling being 345.37% after 21 days of storage as compared to all other cakes and the control samples followed by cake made from substituted at the same levels of watermelon rinds powder.

### *Peroxide and acid values of cake samples during storage*

Changes occurring in the PV and AV of cake made from substituted fat with watermelon rinds and sharlyn melon peels at different levels during storage are given in Figs. 3 and 4. The

**Table 13** Moisture content of cake containing substituted fat with different levels of watermelon rind and sharlyn melon peel powders during storage at room temperature for 21 days.

| Storage period (days) | Control (zero) | BHA (0.02%) | Watermelon rinds (%) | | | Sharlyn melon peels (%) | | |
|---|---|---|---|---|---|---|---|---|
| | | | 5 | 10 | 15 | 5 | 10 | 15 |
| Zero | $27.09^{Aa}$ | $25.48^{Ba}$ | $25.16^{Ba}$ | $25.89^{Ba}$ | $25.72^{Ba}$ | $25.34^{Ba}$ | $25.80^{Ba}$ | $25.36^{Ba}$ |
| 7 | $25.25^{Bb}$ | $25.25^{Aa}$ | $24.80^{Aab}$ | $25.30^{Ab}$ | $25.18^{Aa}$ | $25.60^{Aa}$ | $25.32^{Aab}$ | $25.54^{Aa}$ |
| 14 | $22.55^{Dc}$ | $22.59^{Cb}$ | $24.30^{Bab}$ | $24.74^{Bc}$ | $24.62^{Ba}$ | $25.21^{ABa}$ | $25.25^{Aa}$ | $25.28^{ABa}$ |
| 21 | $21.64^{Dc}$ | $22.08^{Bc}$ | $24.12^{Ab}$ | $24.46^{Ac}$ | $24.15^{Aa}$ | $24.70^{Ab}$ | $24.27^{Ab}$ | $24.45^{Ab}$ |

Means values in the same column showed the same superscript small letter are not significantly different ($p \geqslant 0.05$).
Means values in the same row showed the same superscript capital letter are not significantly different ($p \geqslant 0.05$).

**Table 14** Staling of cake containing substituted fat with different levels of watermelon rind and sharlyn melon peel powder storage at room temperature for 21 days.

| Storage period (days) | Control (zero) | BHA (0.02%) | Watermelon rinds (%) | | | Sharlyn melon peels (%) | | |
|---|---|---|---|---|---|---|---|---|
| | | | 5 | 10 | 15 | 5 | 10 | 15 |
| Zero | $379.39^{Fa}$ | $346.12^{Ha}$ | $441.18^{Ba}$ | $438.14^{Ca}$ | $397.98^{Fa}$ | $421.49^{Ea}$ | $474.82^{Aa}$ | $423.82^{Da}$ |
| 7 | $327.24^{Fb}$ | $321.48^{Hb}$ | $407.38^{Db}$ | $429.37^{Ab}$ | $350.73^{Fb}$ | $414.08^{Cb}$ | $418.06^{Bd}$ | $381.96^{Eb}$ |
| 14 | $316.49^{Ec}$ | $301.07^{Hc}$ | $324.63^{Ec}$ | $322.78^{Fc}$ | $339.38^{Bc}$ | $350.38^{Ac}$ | $331.57^{Dc}$ | $338.60^{Cc}$ |
| 21 | $286.56^{Gd}$ | $266.42^{Hd}$ | $323.75^{Bd}$ | $314.70^{Dd}$ | $300.36^{Ed}$ | $345.37^{Ad}$ | $293.64^{Fd}$ | $322.03^{Cd}$ |

Means values in the same column showed the same superscript small letter are not significantly different ($p \geqslant 0.05$) Means values in the same row showed the same superscript capital letter are not significantly different ($p \geqslant 0.05$).

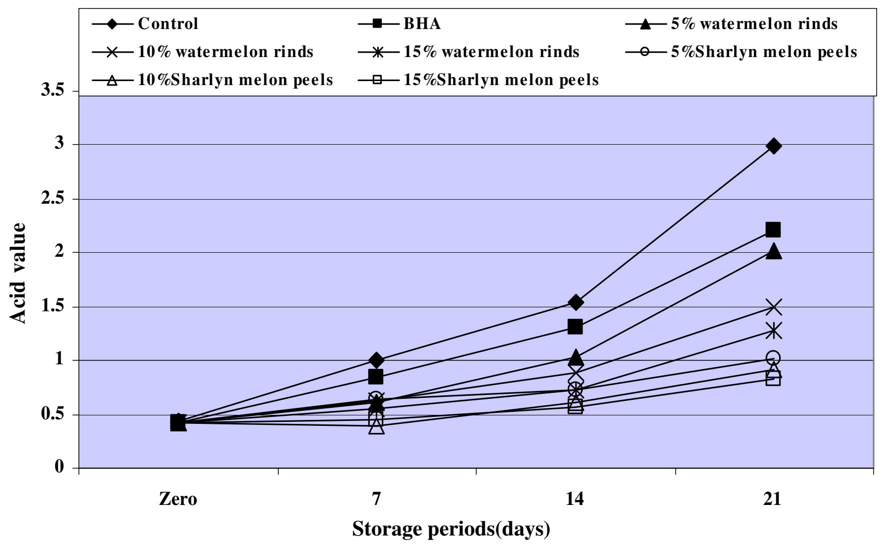


**Fig. 3** Acid value of cake containing substituted fat with different levels of watermelon rind and sharlyn melon peel powders during storage at room temperature for 21 days.

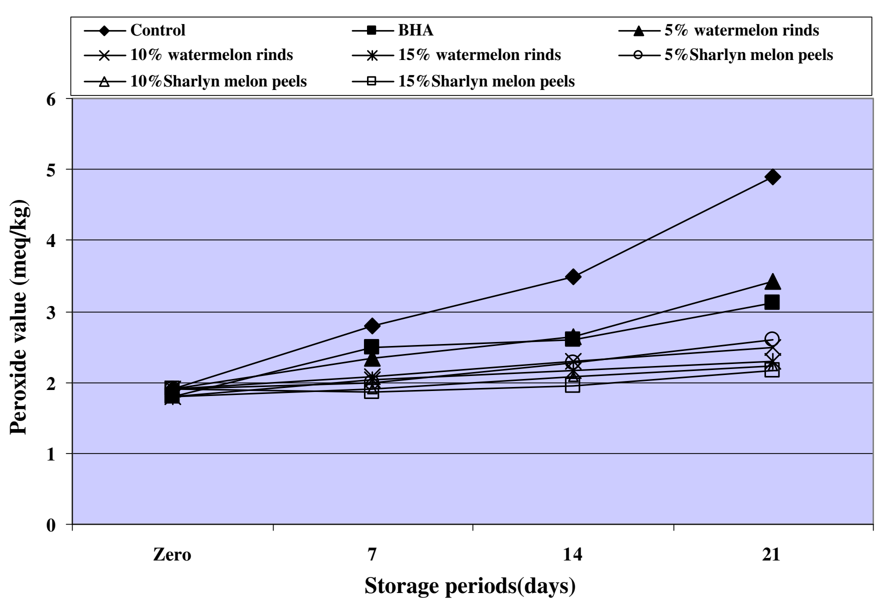


**Fig. 4** Peroxide values of cake containing substituted fat with different levels of watermelon rind and sharlyn melon peel powders during storage at room temperature for 21 days.

PV of all treatment decreasing with increased the level of watermelon rinds and sharlyn melon peels.

An increased in PV and AV was observed in all the cake samples on storage. The increases were considerably higher in control cake sample compared to cake samples in which synthetic BHA or watermelon rinds and sharlyn melon peels powder containing natural antioxidants were incorporated. A slow and gradual increases was observed indicating the potency of antioxidant of watermelon rinds and sharlyn melon peels in inhibiting the formation of free acids and peroxides.

*Sensory evaluation of cake samples during storage*

Table 15, indicated that the sensory scores of cake made from fat substituted with different levels of watermelon rind and sharlyn melon peel powders were significantly affected. Cake containing fat substituted with 5% and 10% watermelon rind and sharlyn melon peel powders received significantly superior scores at zero time and during storage compared to cakes containing 15% of substituted materials as fat replaces in all the quality attributes, being statistically equal to those of control sample. Storage of different cake samples for 21 days significantly reduced all their sensory properties. The minimum reduction in score values was observed in cake containing fat substituted with 10% sharlyn melon peels followed by 5% watermelon rind and sharlyn melon peel powders then 10% of watermelon rind powders; the maximum reduction was observed by the control sample. The obtained results revealed that 5% substitution of fat with watermelon rind and sharlyn melon peel powders produced an acceptable cake which were not significantly different from the control.

**Table 15** Statistical analysis of scores of sensory properties of cake substituted fat with different levels of watermelon rind and sharlyn melon peel during storage at room temperature for 21 days.

| Storage period (days) | Control | BHA (0.02%) | Watermelon rinds (%) | | | Sharlyn melon peels (%) | | |
|---|---|---|---|---|---|---|---|---|
| | | | 5 | 10 | 15 | 5 | 10 | 15 |
| *Appearance* | | | | | | | | |
| Zero | $8.60^{ABa}$ | $8.80^{Aa}$ | $8.40^{ABCa}$ | $8.20^{ABCa}$ | $7.80^{BCa}$ | $8.40^{ABCa}$ | $8.40^{ABCa}$ | $7.60^{Ca}$ |
| 7 | $7.20^{Bb}$ | $7.60^{ABb}$ | $7.80^{ABab}$ | $8.00^{ABa}$ | $7.40^{ABab}$ | $8.20^{Aa}$ | $7.6^{ABb}$ | $7.60^{ABa}$ |
| 14 | $7.80^{ABab}$ | $7.60^{ABCb}$ | $7.80^{ABab}$ | $7.60^{ABCa}$ | $6.60^{Dbc}$ | $8.00^{Aa}$ | $7.20^{BCDb}$ | $7.00^{CDa}$ |
| 21 | $7.40^{Ab}$ | $7.40^{Ab}$ | $7.40^{Ab}$ | $7.40^{Aa}$ | $6.20^{Bc}$ | $7.40^{Ab}$ | $7.20^{Ab}$ | $6.80^{ABa}$ |
| *Crust color* | | | | | | | | |
| Zero | $8.20^{ABa}$ | $8.80^{Aa}$ | $8.40^{ABa}$ | $8.20^{ABa}$ | $8.00^{ABa}$ | $8.20^{ABa}$ | $8.20^{ABa}$ | $7.80^{Ba}$ |
| 7 | $8.00^{Aa}$ | $8.00^{Ab}$ | $8.00^{Aab}$ | $8.00^{Aab}$ | $7.60^{Aa}$ | $7.80^{Aab}$ | $7.60^{Aab}$ | $7.20^{Aab}$ |
| 14 | $8.00^{Aa}$ | $7.40^{ABbc}$ | $7.60^{ABb}$ | $7.20^{Bb}$ | $6.40^{Cb}$ | $7.60^{ABab}$ | $7.20^{Bb}$ | $7.00^{BCab}$ |
| 21 | $7.80^{Aa}$ | $7.20^{ABCc}$ | $7.00^{BCDc}$ | $7.20^{ABCb}$ | $6.50^{Db}$ | $7.20^{ABCb}$ | $7.4\ 0^{ABab}$ | $6.60^{CDb}$ |
| *Crumb color* | | | | | | | | |
| Zero | $8.40^{Aa}$ | $8.40^{Aa}$ | $8.40^{Aa}$ | $7.80^{Aa}$ | 7.20Aa | 8.2Aa | $8.00^{Aa}$ | $7.80^{Aa}$ |
| 7 | $7.80^{Aab}$ | $7.60^{Abc}$ | $8.00^{Aa}$ | $7.60^{Aa}$ | $7.40^{Aa}$ | $7.8^{Aab}$ | $7.60^{Aa}$ | $7.4^{Aa}$ |
| 14 | $8.00^{ABab}$ | $8.0^{ABab}$ | $8.20^{Aa}$ | $7.8A^{Ba}$ | $6.60^{Dab}$ | $7.60^{ABCab}$ | $7.4^{BCa}$ | $7.00^{CDab}$ |
| 21 | $7.60^{Ab}$ | $7.20^{Ac}$ | $7.60^{Aa}$ | $7.40^{Aa}$ | $5.80^{Bb}$ | $7.20^{Ab}$ | $7.20^{Aa}$ | $6.40^{Bb}$ |
| *Crumb texture* | | | | | | | | |
| Zero | $8.60^{Aa}$ | $8.60^{Aa}$ | $8.40^{ABa}$ | $8.40^{ABa}$ | $8.20^{ABa}$ | $8.20^{ABa}$ | $8.20^{AB}$a | $7.8^{Ba}$ |
| 7 | $7.60^{Ab}$ | $7.60^{Ab}$ | $8.00^{Aab}$ | $7.40^{Ab}$ | $7.20^{Ab}$ | $7.60^{Aab}$ | $7.6^{Aab}$ | 7.4 0Aa |
| 14 | $7.60^{Ab}$ | $7.20^{Ab}$ | $7.60^{Aab}$ | $702^{Ab}$ | $6.80^{ABb}$ | $7.00^{Ab}$ | $7.2^{Ab}$ | $6.20^{Bb}$ |
| 21 | $7.00^{Ab}$ | $5.80^{Bc}$ | $7.20^{Ab}$ | $7.00^{Ab}$ | $5.80^{Bc}$ | $7.20^{Ab}$ | $7.40^{Ab}$ | $5.60^{Bb}$ |
| *Taste* | | | | | | | | |
| Zero | $8.40^{Aa}$ | $8.20^{Aa}$ | $8.40^{Aa}$ | $8.40^{Aa}$ | $8.00^{Aa}$ | $8.60^{Aa}$ | $8.60^{Aa}$ | $8.00^{Aa}$ |
| 7 | $8.00^{ABa}$ | $8.00^{ABa}$ | $8.40^{Aa}$ | $8.00^{ABab}$ | $6.80^{Db}$ | $7.60^{BCb}$ | $7.00^{CDb}$ | $7.00^{CDb}$ |
| 14 | $7.00^{ABb}$ | $7.20^{Ab}$ | $7.40^{Ab}$ | $7.20^{Aab}$ | $6.40^{Bb}$ | $6.80^{ABb}$ | $7.20^{Ab}$ | $6.40^{Bab}$ |
| 21 | $6.80^{ABCb}$ | $6.40^{BCDc}$ | $7.40^{Ab}$ | $7.00^{ABb}$ | $6.20^{CDb}$ | $7.20^{Ab}$ | $7.00^{ABb}$ | $6.00^{\ Db}$ |
| *Odor* | | | | | | | | |
| Zero | $8.00^{Aa}$ | $7.80^{Aa}$ | $8.40^{Aa}$ | $8.00^{Aa}$ | $7.80^{Aa}$ | $8.60^{Aa}$ | $8.40^{Aa}$ | $8.00^{Aa}$ |
| 7 | $7.00^{Cb}$ | $7.40^{BCa}$ | $8.40^{Aa}$ | $7.80^{ABa}$ | $7.00^{Ca}$ | $8.00^{ABa}$ | $8.00^{ABab}$ | $7.40^{BCa}$ |
| 14 | $6.60^{CDbc}$ | $7.80^{Aa}$ | $7.40^{ABCb}$ | $7.00^{ABCDb}$ | $5.60^{Eb}$ | $6.80^{BCDb}$ | $7.60^{ABab}$ | $6.20^{DEb}$ |
| 21 | $6.20^{CDc}$ | $6.40^{BCDb}$ | $7.00^{ABb}$ | $6.80^{ABCb}$ | $5.40^{Ab}$ | $6.80^{ABCb}$ | $7.20^{Ab}$ | $8.50^{DEb}$ |
| *Overall acceptability* | | | | | | | | |
| Zero | $8.20^{ABCa}$ | $8.00^{ABCa}$ | $8.60^{ABa}$ | $8.00^{ABCa}$ | $7.40^{Ca}$ | $8.40^{ABa}$ | $8.80^{Aa}$ | $7.80^{BCa}$ |
| 7 | $8.00^{Aa}$ | $8.00^{Aa}$ | $8.40^{Aa}$ | $8.00^{Aa}$ | $7.00^{Bab}$ | $8.00^{Aa}$ | $7.60^{ABb}$ | $7.00^{Bb}$ |
| 14 | 7.40Aa | $7.00^{ABCab}$ | $7.60^{Ab}$ | $7.20^{ABb}$ | $6.40^{BCb}$ | $7.20^{ABb}$ | $7.60^{Ab}$ | $6.20^{Cc}$ |
| 21 | $6.60^{BCb}$ | $6.40^{CDb}$ | $7.20^{ABb}$ | $7.20^{ABb}$ | $5.60^{Ec}$ | $7.20^{ABb}$ | $7.60^{Ab}$ | $5.80^{DEc}$ |

Means values in the same column showed the same superscript small letter are not significantly different ($p \geqslant 0.05$).
Means values in the same row showed the same superscript capital letter are not significantly different ($p \geqslant 0.05$).

## Conclusion

A successful and novel formulation of cake production with watermelon rinds and sharlyn melon peel powders were developed. Watermelon rinds and sharlyn melon peels are good sources of phenolic compounds and dietary fiber. Cake batter formulated with partial substitution of flour or fat with 5% watermelon rind or sharlyn melon peel powders had bioactive components as compared to cake prepared with 100% wheat flour. Watermelon rind and sharlyn melon peel were good in antioxidant activity to increase shelf-life of cake. Substitution of wheat flour at 5% is recommended to produce an acceptable cake. Overall, it could be recommended that the technology of using watermelon rind and sharlyn melon peel powders should be encouraged among food industries to make economic use of local raw materials to incorporate into cake and provide cake with more functional components and more effective antioxidant activity.

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