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Chemical and Technological Studies on Pink Grapefruit (*Citrus paradise* L.) Peels. 2- Physicochemical Properties and Technological Quality of Cake Fortified with Different Levels of Pink Grapefruit (*Citrus paradise* L.) Peels Powder

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Abstract: Grapefruit is considered a fruit of good nutritional value provide us with many useful nutrients and has many benefits in the food processing. Also the grapefruit peels contain innumerable nutrients and used in the making of jam and desserts. The current study aimed to utilize the whole grapefruit peels powder in cake fortification. Study included determination of gross chemical composition, caloric value, physical, sensory properties of the studied cakes likewise; staling rate and loss of freshness of studied cakes were assessed. The data revealed that incorporation of both wheat flour and treated whole grapefruit peels powder (TGPP) increased moisture, ash and crude fiber to (25.51%- 28.45%); (3.95%-4.42%) and (0.81%-2.22%); respectively. The results showed that 5%, 10%, 15% and 20% TGPP had a different effect on all studied sensory and physical characteristics of all studied cakes. Moreover, cake with 5%, 10% TGPP was recorded the best scores of all studied sensory characteristics in fortified cakes. The staling rate mean values of the different cake samples were reduced gradually during storage for 2, 4, 6 and 8 days. The higher freshness (27.21%) was assessed in cakes fortified with 15% TGPP. The results showed that cake fortified with 20% TGPP had the highest staling value (362.20%) after 8 days of storage as compared to all other cakes samples. Consequently, it recommended utilizing the grapefruit peels to enhance the nutritional values of cake.

Key words: Grapefruit peels · Chemical composition · Cake · Staling · Physical and Sensory Characteristics

INTRODUCTION

The food processing industry generates a huge quantity of by-products, including pomace, peel, husks, pods, stems, bran, washings, press cakes, etc., which have a lower production value and create considerable environmental pollution [1]. Citrus pomace is generated in large quantities as a by-product of processing this fruit during the production of juice and it mainly consists of peel and seeds. Aside from their use in the production of pectin, citrus peel and seeds have significant antioxidant potential, so their application has recently been steadily increasing [2].

The genus *Citrus* includes several important fruits, with the most important on a worldwide basis being sweet orange (*C. sinensis*: 61.1 % of world citrus production), tangerine (*C. reticulata*: 19.9 %), lemon and lime (*C. limon* and *C. aurantifolia*: 12.1 %) and grapefruit (*C. paradisi*: 5.0 %). Minor citrus genuses that comprise the bulk of the remaining 2.0 % include sour orange (*C. quarantium*), shaddock (*C. grandis*), citron (*C. medica*) [3].

Citrus by-products are the principal solid derivatives of the citrus processing industry and constitute about 50 % of fresh fruit weight. They contain the peel (60-65 %), internal tissues (30–35 %) and seeds (0–10 %). Until comparatively recently these waste products led to significant disposal problems, since there was no satisfactory means of disposal other than dumping on land adjacent to the production sites. This led in some regions to the generation of large tracts of land containing

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significant quantities of putrefying waste which presents a significant risk to local water courses and in some cases leads to uncontrolled methane production. The major environmental problem associated with citrus peel is its highly fermentable carbohydrate content which accelerates its degradation when not carefully managed [4, 5].

The idea of utilizing fruit by-products mainly the peels which in some fruits represent almost 30% of the total weight, have slowly gaining popularity especially when researchers found that peels possessed better biological activities than other parts of the fruit [6]. More recently, with the increasing interest for fruit peels are been developed. However the potential application of fruit peels in food supplementation depends strongly on their chemical composition [7, 8].

Citrus fruits are the most consumed fruits in world wide. They produce large amounts of useful by-products such as essential oil [9]. Grapefruit belongs to genus citrus and family of *Rutaceae*. Citrus peels ranges from 50 to 65 % of total fruit weight and act as a primary by product [10].

Peel of grapefruit consists of flavedo (epicarp, exterior yellow peel) and albedo (mesocarp, spongy white layer). Albedo is rich in pectin and dietary fiber. Fibers from fruit source not only provide energy but also important for maintaining healthy and balanced diet. Citrus fiber prevents from intestinal constipation. Fiber helps in lowering a tracolonic pressure, which also reduces the chances of diverticular disease such as colon cancer and hemorrhoids. It prevents from plaque formation and dietary fat cholesterol pool which is a component of cholesterol, fats and proteins [11].

Cakes are important bakery products. Their worldwide market currently grows with about 1.5% a year. Challenges in the cake market include cost reduction, increased shelf life and quality control. Cake making consists of mixing the ingredients into a batter which, because of the high level of liquid phase in cake recipes, has a low viscosity and baking such batter into cake [12].

Wheat-flours used in cake elaboration have lower protein content and it is known that one of the most important characteristics of cake elaboration flours is particle size [13]. Gluten does not play an important role in this kind of product, which means that flours from other cereals [14 - 16] or even from pulses, such as chickpeas or lupine [17] can be used.

Cakes belong to the group of cellular solid foods that have air pockets embedded in a protein and starch network. Baking process consist of three different stages. In the initial stage, batter expansion and moisture loss occurs which is followed by further moisture loss and volume rise reaching to a maximum final stage where air pockets are entrapped inside a food matrix [18]. A good quality cake should have high volume with a fine uniform moist crumb. The cake structure can be set by formation of a protein-starch network in circumstances where the expansion of each bubble dominates over destructive events such as coalescence and disproportionation [19]. Cakes contain high amounts of sugar, shortening, egg, milk or water together with soft wheat flour. The airy structure of cakes comes from oil/ water emulsion or foam from egg proteins during mixing. Cake quality is strongly dependent on the type of ingredients, formulation and baking conditions. The basic ingredients in a cake batter are flour, fat, egg, milk, sugar and salt. Flour, egg white, milk solids and salt are used to toughen the cake whereas sugar, fat and egg yolk are used to tenderize the cake. Cake batter consists of oil/water emulsion with dry ingredients. The oil part is dispersed in the liquid phase [20].

Foam formation occurs during mixing where air cells are introduced into the batter. The higher number of air pockets the higher the volume. Starch gelatinization, protein denaturation together with carbon dioxide formation gives cake its porous, soft structure. The degree of expansion is dependent on the viscosity of the batter. If the batter is thick, it would be difficult for the air bubbles to escape, which would result in a high volume cake. A low viscosity batter will fail to hold the air cells in the structure resulting in a low volume cake. However, it is so important to achieve the optimum viscosity batter since a high viscosity batter might restrict expansion during baking and result in low volume [21, 22].

After baking, all bakery products undergo a series of chemical and physical changes which are referred to as staling. These physical-chemical changes will cause crumb firming and loss of moisture, softness and elasticity leading to consumer rejection even if there is no health concern. Staling results in loss of freshness and quality of the baked product. The most important change associated with staling is the gradual increase in the firmness of the baked product. The term firmness refers to the force necessary to attain a given deformation. It is known that starch retrogradation implies hardening of the starch gel, therefore it is supposed to be responsible for the increased firmness of the stale product [23, 24].

Starch retrogradation is mostly influenced by three factors: temperature, specific volume of the baked product and moisture content [25]. Guy [26] reported that the overall firming of cakes consisted of two separate processes: a firming effect caused by moisture transfer from crumb to crust and an intrinsic firming of cell wall material which was associated with starch retrogradation during storage. Functionality of the ingredients is important for cake staling. Ingredients such as sugar and fat have softening effects on cakes, but eggs have firming effects.

The aim of this study is to determine the effect of adding 5%, 10%, 15% and 20% of grapefruit peels powder instead of wheat flour in the cake processing on chemical composition as well as physical and sensory properties. In addition, study the effect of these additions on the staling and freshness of cake.

MATERIALS AND METHODS

Materials: Pink grapefruit (*Citrus paradise* L) foster variety was brought from botanical farm - Faculty of Agriculture - Assiut University in March 2017.

The Bitterness Treatment: Mature grapefruits were washed and the peels were removed, then the peels were further cut into small pieces for easy drying. Put the peels in a sauce (stainless steel or pyrex) pan, cover with a generous amount of water and bring to a boil. Let boil for 15 minutes. Washing with large quantity of water to remove the bitter taste of the peels then air dried, milled to obtain whole grapefruit peels powder and stored in freezer until processing. Ingredients of cake (wheat flour, egg, oil …..ect) were obtained from local super market.

Methods

Chemical Composition: Moisture, crude protein, crude oil and ash were determined as described in the AOAC Methods [27]. The total carbohydrates were calculated by difference according to Pellet and Sossy [28]. The caloric value was calculated using value of 4 k.cal/g protein, carbohydrates and 9 k.cal/g fat according to Livesy [29]. Triplicate determinations were carried out for each sample and the means were reported.

Preparation of Cakes: The corn oil (31.83g) was beaten thoroughly, the sugar (75g) was added to butter and mixed until got smooth like cream and then a well-blended egg (39.75g) with vanilla (1.5g), dry milk (14.76g), oil (125 ml) were added and mixed together. The blends (150g) of white fine wheat flour (72%) with treated whole grapefruit peels powder (TGPP), salt (3.4g), baking powder (6.81g) were stirred together and added alternately to the egg mixture. The mixture was whipped until got smooth. The dough transferred to a greased pan and was baked for 25 min. at 200±5°C then was cooled at room temperature [30]. Cakes were prepared according to the formula is shown in Table (1).

Physical Characteristics for Cakes: The weight (g), the volume (cm^3) and specific volume (cm^3/g) for cake were determined according to the methods of A.A.C.C. [30], the weight (g) for cake was determined individually within one hour after baking the average was recorded. The volume (cm^3) of different types of produced cakes was determined by displacement method with clover seeds. Specific volume was calculated using the following Equation: Specific volume = Volume (cm^3)/Weight (g).

Stalling Rate: The staling rate of different prepared cake samples was determined after baking within one hour and after 2, 4 and 6 days of storage at room temperature (22±4°C) by alkaline water retention capacity (AWRC %) according to A.A.C.C. [30].

Loss of Freshness: The loss of freshness was calculated by means of the following equation:

$$\text{Loss of freshness (\%)} = \frac{\text{AWRC at 0-time - AWRC after interval (days) X 100}}{\text{AWRC at 0-time}}$$

Table 1: Formulation of cake fortified by whole grapefruit peels Powder at different levels

Ingredients (g)	Control	1	2	3	4
White fine wheat flour (72% extraction)	150.00	142.50	135.00	127.50	120.00
Treated whole grapefruit peels powder	--	7.50	15.00	22.50	30.00
Baking powder	6.81	6.81	6.81	6.81	6.81
Sugar	75.00	75.00	75.00	75.00	75.00
Salt	3.40	3.40	3.40	3.40	3.40
Corn oil	31.83	31.83	31.83	31.83	31.83
Fresh whole egg	39.75	39.75	39.75	39.75	39.75
Skim dry milk	14.76	14.76	14.76	14.76	14.76
Vanilla	1.50	1.50	1.50	1.50	1.50

Sensory Evaluation of Cake: The sensory evaluation of cake was measured by a panel of ten judges from the staff of Food science and Technology department, Faculty of Agriculture, Assiut University. The evaluation of cake samples was done by using scoring system according to A.A.C.C. [30]. The panelists were asked to evaluate each cake for crumb color, graining of crumb, texture, crust color, taste, odor and overall acceptability. A 10 point scale was used where 10"excellent and 1"extremely unsatisfactory.

Statistical Analysis: The experimental data were subjected to an analysis of variance (ANOVA) for a completely randomized design using a statistical analysis system [31].

RESULTS AND DISCUSSION

Gross Chemical Composition of Cakes: The chemical composition of wheat flour 72% extraction and treated grapefruit peels powder (TGPP) are shown in Table (2). Results indicated that TGPP was lower in crude protein (9.26%), caloric value (352.08), while it was higher in crude fiber (11.84%), ash (3.59%) and oil (2.76%) as compared with wheat flour 72% extraction.

The moisture content of cakes samples was ranged from 25.51% to 28.45% (Fig. 2). Addition of TGPP caused a significant ($P<0.05$) increasing in moisture content for the fortified cakes samples as compared with control cake. This may be due to the method or higher content of crude fiber in grapefruit peels which used in supplementation or other ingredients used in the processing of the cake.

Gross chemical composition of cake containing treated grapefruit peels powder (g/100g dry weight) are shown in Table (3). More significantly ($P<0.05$) was observed in the ash and crude fiber contents which increased in all TGPP cakes samples than control. The ash content in TGPP cakes was ranged from 4.15% to 4.42% as compared with 3.95% for control. The crude fiber was increased gradually with increment of tgpp percent with values 1.00%, 1.37%, 1.80% and 2.22% for tgpp 5%, TGPP10%, TGPP15% and TGPP 20%, respectively, this results could be due to higher content of crude fiber in TGPP compared to wheat flour so the addition of TGPP to cakes led to increment of crude fiber content. There were no significant ($P<0.05$) differences in protein content between the control; 14.66% which contained 100% wheat flour and the other TGPP cakes with values ranged from 14.88% to 15.32%.

The oil content in wheat flour was significantly higher; 27.99% than the other TGPP cakes samples with values ranged from 23.27% to 27.61%. As shown in Table 3, there were significant increases in the amounts of carbohydrates in TGPP5%, TGPP 20% cake, while the amount of carbohydrates decreased in TGPP10% and TGPP15% cake when compared to control.

The data revealed that all TGPP cakes were decreased significantly ($P<0.05$) in energy (Kcal/100 g) from 515.33 to 489.79 compared with the control (520.91).

Sensory Evaluation and Physical Properties of Cakes: Sensory evaluation and physical properties of cakes made from wheat flour and its mixtures with treated whole grapefruit peels powder (g/100g dry weight) showed in Table (4) and Fig. (2). The crust color, crumb properties, texture, taste, odor, over all acceptability scores of control WF sample and 5%, 10%, 15%, 20% TGPP samples were significantly ($P<0.05$) different. Incorporation of TGPP in cake samples recorded lower values for all sensory attributes than control WF cake. The total scores of was decreased significantly from 62.37 for control WF cake to 58.95, 56.80, 52.22, 50.75 for 5%, 10%, 15%, 20% TGPP samples, respectively. However, the data in Table (4) revealed that the best scores between TGPP cake samples for all studied sensory properties was recorded for 5% fortified cake with TGPP. As shown in Fig. (2), the crust color of cakes was affected by the addition of TGPP.

Weight (g), volume (cm^3) and specific volume (cm^3/g) of cakes containing TGPP was presented in Table (3) and Fig. (2). The incorporation of TGPP in cakes increased significantly ($P<0.05$) all the physical properties as compared with control. The cake weight was increased from 459.16 for control WF to 468.68, 475.59, 482.99 and 501.01g for 5%, 10%, 15% and 20% TGPP samples, respectively. However, the results from Fig. (2) revealed that with the different replacement ratios of TGPP, the cake volume, specific volume increased in all blends, especially TGPP 15% with values 1170.20 cm^3, 2.42 cm^3/g compared with 884.30 cm^3 and1.93 cm^3/g for control WF, respectively. The increase in the weight of the cake may be due to water retention and this is evident from the increase in the moisture content of the fortified cake with TGPP , while the increase in the volume of the cake due to increase of crude fiber content in TGPP. Our results were agreement with Singh *et al.* [32] who, reported that cake volume and specific volume significantly increased with increased level of fiber.

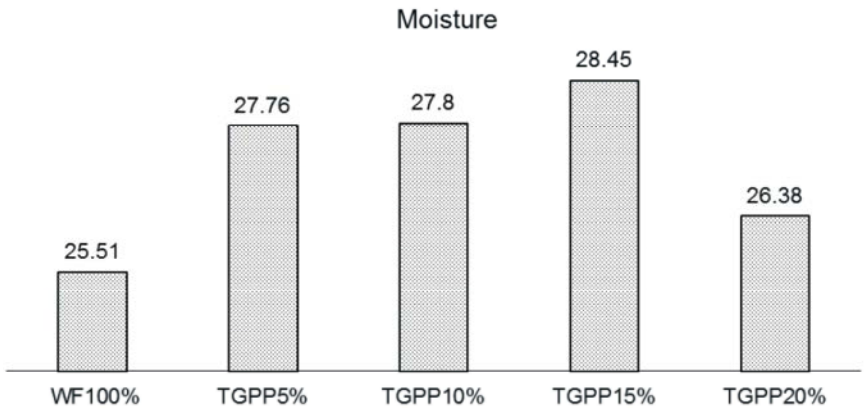

Fig. 1: Moisture content of cake containing wheat flour (WF) and treated grapefruit peels powder (TGPP)

Table 2: Gross chemical composition of wheat flour and treated grapefruit powder (g/100g) on dry weight basis*.

	Flour samples	
Parameters%	Wheat flour 72% extraction	Treated grapefruit peels powder
Moisture	12.12	12.62
Ash	0.63	3.59
Crude protein	12.85	9.26
Oil	1.57	2.76
Crude fiber	0.82	11.84
Total carbohydrates**	84.13	72.55
The caloric value (Kcal/100g)	402.05	352.08

* Mean of three replicates ** Calculated by difference

Table 3: Gross chemical composition of cake containing treated grapefruit peels powder (g/100g dry weight).

Sample	Ash	Crude Protein	Oil	Crude fiber	Total carbohydrates	The caloric value (Kcal/100g)
Control WF*	3.95	14.66	27.99	0.81	52.59	520.91
WF + TGPP** 5%	4.15	15.10	24.15	1.00	55.60	500.15
WF + TGPP 10%	4.31	15.21	27.61	1.37	51.50	515.33
WF + TGPP 15%	4.41	15.32	26.05	1.80	52.42	505.41
WF + TGPP 20%	4.42	14.88	23.27	2.22	55.21	489.79
L.S.D 0.05	0.18	0.66	1.16	0.07	2.35	15.04

*WF= wheat flour. **TGPP = Treated whole grapefruit peels powder

Table 4: Sensory evaluation and physical properties of cakes made from wheat flour and its mixtures with treated whole grapefruit peels powder

	Sensory evaluation								Physical properties		
		Crumb									
Sample	Crust color (10)	Color (10)	Graining (10)	Odor (10)	Texture (10)	Taste (10)	Over all Acceptability (10)	Total score (70)	Volume (cm^3)	Weight (g)	Specific volume (cm^3/g)
Control WF*	9.10	8.88	8.78	8.75	8.88	9.10	8.88	62.37	884.30	459.16	1.93
WF + TGPP** 5%	8.88	8.64	8.20	8.38	8.25	8.50	8.10	58.95	962.60	468.68	2.05
WF + TGPP 10%	8.20	8.20	8.05	8.10	8.05	8.10	8.10	56.80	1058.40	475.59	2.23
WF + TGPP 15%	7.88	7.59	7.50	7.65	7.50	7.05	7.05	52.22	1170.20	482.99	2.42
WF + TGPP 20%	7.65	7.05	7.50	7.50	7.05	7.00	7.00	50.75	1065.50	501.01	2.13
L.S.D 0.05	0.45	0.36	0.36	0.38	0.36	0.58	0.48	2.55	43.53	20.68	0.47

*WF= wheat flour. **TGPP = Treated whole grapefruit peels powder

Fig. 2: Cake samples substituted with 5%, 10%, 15% and 20% treated grapefruit peels powder.

Table 5: Staling rate and loss of freshness of cake samples substituted with 5%, 10%, 15% and 20% treated grapefruit peels powder during storage period at room temperature (22±4 °C)

	Staling rate by AWRC					Loss of freshness%				
Cake sample	0 time	2 days	4 days	6 days	8 days	0 time	2 days	4 days	6 days	8 days
Control WF*	364.50	328.13	296.65	242.79	226.42	--	9.99	18.88	33.39	38.71
WF + TGPP** 5%	411.54	387.36	348.48	317.03	295.32	--	5.87	15.32	22.97	28.24
WF + TGPP 10%	431.23	412.48	371.56	338.17	301.25	--	4.35	13.84	21.58	30.14
WF + TGPP 15%	463.81	426.70	406.21	350.22	337.62	--	8.00	12.42	24.49	27.21
WF + TGPP 20%	516.33	494.06	462.12	395.26	362.20	--	4.31	10.50	23.45	29.85
L.S.D 0.05	A		41.26					3.44		
	B		33.23					7.33		
	AB		45.22					7.92		

*WF= wheat flour. **TGPP = Treated whole grapefruit peels powder

Staling Rate and Loss of Freshness of Cake Samples During Storage: It is known that the responsible for the phenomenon of staling in the cake is the starch retrogradation and as a result of the water out of the chains of amylose and then out of the crumb to the crust, leading to drought in the crust and a lack of cake freshness [23]. Staling rate and loss of freshness of cake samples substituted with 5%, 10%, 15% and 20% treated grapefruit peels powder during storage period at room temperature (22±4°C) are tabulated in Table (5). From these data the staling rate by AWRC was decreased significantly (P<0.05) during storage from 0 time to 8 days. The results in Table (5) showed that cake fortified with 20% TGPP had the highest staling value (362.20%) after 8 days of storage as compared to all other cakes samples. The control WF cake had the lowest staling values; 364.50%, 328.13%, 296.65%, 242.79%, 226.42% after 0, 2 s, 4, 6 and 8 days of storage, respectively. On the other hand, the control sample recorded the highest value in the loss of freshness until it reached to 38.71% at the end of the storage period. For grapefruit-fortified samples, they recorded lower values for loss of freshness, ranging from 27.21% to 30.14 and recorded the highest values in staling rate ranging from 295.32% to 362.20% at the end of storage. Therefore, it is clear that the reinforcement of the cake with different proportions of TGPP has increased the quality of the cake by increasing the staling rate and the decreasing in the loss of freshness.

CONCLUSION

The addition of grapefruit peels at different proportions of 5%, 10%, 15% and 20% instead of wheat flour in the processing of cake has improved their physico-chemical properties as well as the quality of the cake resulting in increasing the ash, crude protein, crude fiber contents and decrease the oil ratio and caloric value compared to the cake made from wheat flour.

It is therefore possible to recommend the use of grapefruit peel fruits after treatment for the removal of bitterness in the strengthening of cake as well as some other products used to treat obesity and weight loss.

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