Research Article

Effect of Grape Fruit Albedo Powder on the Physicochemical and Sensory Attributes of Fruit Cake

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Abstract | In thisstudy, fruit cakes were made by replacing fat in different proportion with grape fruit albedo powder. The effect of fiber source on physicochemical, sensory attributes and microbiological properties of fruit cakes were examined during 30 days of storage. Results showed that with varying fiber content water activity, texture, color, moisture, fat, protein, ash, NFE and fiber content changed significantly ($p<0.05$). Gross energy level in cake which is desirable by consumers was reduced but high fiber cake was dark colored, low in volume and with increased hardness. Treatment (T_3) containing 5.6g grapefruit albedo powder shows significantly ($p<0.05$) higher sensory scores in term of color (8.02±0.50), flavor (8.04±0.29), taste (8.18±0.37), mouth feel (8.03±0.41) and overall acceptability (7.84±0.28) during 30 days of storage. It is concluded that grapefruit albedo fiber could be utilized as a source of fiber to further enhance the nutritional potential of fruit cake.

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Introduction

Across the globe food processing industry has been grown and still growing continuously. Importance of bioactive compounds and their health benefits are well known by food processing industry (Sharma et al., 2016).This knowledge led to popularity of functional foods. Functional foodsare helpful to reduce chronic diseases and have health benefits beyond basic nutrition. It was observed that non-nutrient components of food are also very important for health maintenance. This concept provoke the scientists to explore functional ingredients such as phenolic compounds, dietary fiber, phytoestrogen, lignans, etc. (Sharma, 2010; Sharma et al., 2012).

Cakes are defined as the baked goods with high sugar and fat contents, like cookies. It is typically made of wheat flour, sugar, shortening, and egg. Various efforts have made to reduce the fat and calorie contents in cakes by replacing shortenings. Hydrocolloids such as xanthan and guargum are commonly used as fat replacers in baked goods such as cakes (Zambranoet al., 2004). Kalinga and Mishra (2008) used β-glucan concentrate as fat replacer in low calorie cake. Cakes with low fat contents were also produced using ingredients derived from various cereal sources, such as corn (Kim et al., 2001), rice (Inglettet al., 2004), oat

(Lee et al., 2005). Lim et al. (2014) used pectin as fat replacer in cake while Majzoobi et al. (2014) studied oat fiber effect on cake characteristics.

Citrus fruits are the most consumed fruits in world wide. They produce large amounts of useful by-products such as essential oil (Schieber, 2001). Grapefruit belongs to genus citrus and family of Rutaceae (Sozmen, 2011).Citrus peels ranges from 50 to 65 % of total fruit weight and act as a primary by product. If not processed properly, it can be further utilized for making west odor, harborage for insects and soil pollution which create environmental pollution (Bennett, 2006). Peel of grapefruit consists of flavedo (epicarp, eterior 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 (Akobundo, 1999). Recently, there is great demand in finding different ways to utilize food waste. Supplementation is commonly used method to improve fiber content in foods. So keeping in view the health benefits of grapefruit peel fiber, this study was designed to utilize and explore the effect of grapefruit albedo flour on composition and physical parameters of cake.

Materials and Methods

Present research project was conducted at Institute of Food Science and Nutrition, University of Sargodha, Sargodha. Raw materials such as grapefruit, sugar, flour, ghee, eggs and baking powder were purchased from the local market of Sargodha. Chemicals for analysis were purchased from Sigma Aldrich (Seelze, Germany) and Lab-Scan (Dublin, Ireland) available in the local market.

Preparation of grape fruit albedo powder

Grapefruit peel was separated into albedo and flavedo portion. The albedo was cut into small pieces, and placed in oven tray for drying at 70°C for 2 hrs. Dried peels were then ground to a fine powder in grinder. Tricalcium Phosphate (5g) was also added as an anti-caking agent to prevent the lumps formation. The albedo powder was kept in air tight jars for further use.

Preparation of cake

Fruit cake was developed by following the method described by Young et al. (1998). After the preparation of raw materials, ghee and icing sugar were added in a bowl and beat until it forms creamy texture. Then add eggs and beat for another 5 min to make it foamy and creamy. Dry materials (flour, baking powder and grapefruit peel powder, raisins) were mixed and added to form a homogenized batter. This batter was placed in a pre-greased pan and then put in preheated oven at 220°C and bake it for 35 min at 190-200°C. Quantity of albedo powder was varied and used to replace fat while other ingredients were kept constant.

Physical analysis of cake

Water Activity (a_w): Water activity in fruit cake was analyzed by the electronic hygropalm water activity meter (Model Aw-Win, Rotronic, equipped with a Karl-Fast probe). Hygropalm water activity meter is a portable device with 9 Volts battery to measure the water activity and temperature. Firstly, cakes were calibrated and then analyzed according to method as described by Nadeem et al. (2011).

Texture analysis: Texture analyses of cakes were analyzed by texture analyzer with 5 kg load cell (Model TA.XT plus, Stable Microsystems, Surrey, UK) according to the method by Nadeem et al. (2012). The texture expert program version 4.1.2 was used for data analysis. Cake texture was determined by using 3 point bend rig for a bend test. The cakes were bent in order to check structuralability and softness present inside or on the surface. Samples for bending were placed centrally under the 3 point bend rig. Both the load cell and probes were calibrated before test. Hardness measurement of samples by bending involved plotting force (g) versus distance (mm). The maximum force (g) was used as an index of hardness for bend test and maximum distance as fractureabilty.

Color measurement: Color of fruit cake was determined with color meter with the method described by Nadeem et al. (2011) with the help of color meter (Color test II, Neohuaus Neotec). The color meter was calibrated with standards 151 CTn (light color) and 54 CTn (dark color). The samples were placed centrally under photocell of color meter. The reading of the color meter is compared with that of standards.

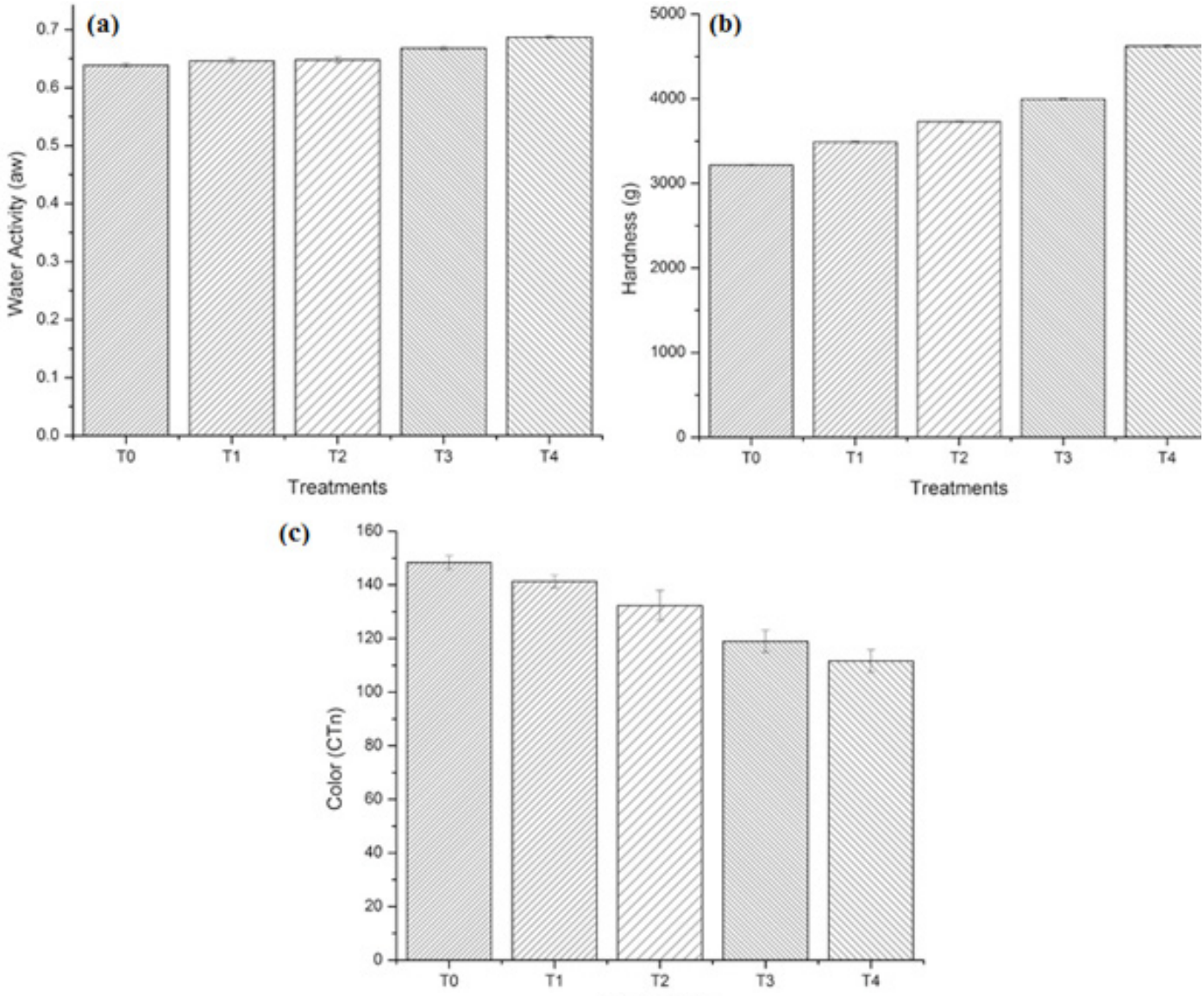

Figure 1: *Effectof different treatmentson the* **(a)** *water activity* **(b)** *hardness and* **(c)** *color, of fruit cake.*
T_0: *without grapefruit albedo flour;* **T_1:** *1.87 g of grapefruit albedo flour;* **T_2:** *3.75g of grapefruit albedo flour;* **T_3:** *5.6 g of grapefruit albedo flour;* **T_4:** *8g of grapefruit albedo flour.*

Table 1: *Formulation of fruit cake (treatment plan).*

Treatment	Sugar (g)	Flour (g)	Eggs (No's)	Albedo powder (g)	Ghee (g)	Raisins (g)	Baking powder (g)
T_0	75	75	2	0	75	5	2
T_1	75	75	2	1.875	73.125	5	2
T_2	75	75	2	3.75	71.25	5	2
T_3	75	75	2	5.60	69.40	5	2
T_4	75	75	2	8.0	67	5	2

Chemical analysis of cake: Proximate analysis of cakes such as crude fat, crude protein, moisture, crude fiber, ash were determined on dry matter basis according to the procedures given in AACC (1999). Gross energy of fruit cake was calculated by using standard factors of 3.75, 9.0 and 3.75 kcal/g for protein, lipid and carbohydrate respectively, the energy contents were summed to give total or gross energy of the fruit cake samples (Livesey, 1990).

Microbiological analysis: Total plate count was done according to method No. 42-11 and Yeast/mold count according to method No. 42-50 of AACC (1999).

Sensory evaluation: Sensory evaluation of fruit cakes were evaluated for sensory characteristics such

as color, appearance, texture, flavor, mouth feel and overall acceptability at 17±5°C by expert panel of 20 judges (12 females and 08 males) from institute of food science and nutrition, University of Sargodha. The evaluation was done in sensory evaluation laboratory by a panel with normal lights on 9-points Hedonic Scale (Land and Shepherd, 1988).

Statistical Analysis

Results were statistically analyzed by using analysis of variance technique (ANOVA). The difference in means was evaluated by the Least Significant Design. This analysis was done by using statistix 9.0 software (Analytical software, Tallahassee, FL) (Steel et al., 1997).

Results and Discussion

Effect of albedo flour on water activity, texture and color of cake

It is apparent from the results (Figure 1) that the water activity differed significantly among different treatments. The water activity of different treatments differed from 0.687 to 0.639. The lowest value was observed in T_o and the highest value was found in case of T_4. It is indicated from the results that there was a gradual increase in water activity with increasing concentrations of dried grapefruit albedo powder in treatments. Water activity is directly related moisture contents.

Texture was measured in terms of hardness. The hardness of different treatments differed from 3217.1g to 4623.2g (Figure 1). This indicates that T_4 had more hardness (4623.2g) than other treatments. The hardness of cakes, which corresponds to a maximum force during compression, had a tendency to increase as more fiber was used. Reduction in aeration of cake batter and heat assisted coagulation of proteins lead to dense structure of cake which in hence cause decrease in volume and increase in cake hardness.It is evident from results that hardness increases with increase in level of replacement with fiber. This trend is in accordance with finding of Lim et al. (2014) who studied use of citrus pectin (fiber source) as fat replacer in baked products. In another study, increase in hardness (1.32 Kg to 4.13kg)was reported by increasing level of β-glucan concentrates in cakes (Kalingaand Mishra, 2009).Similar trend has been reported by Majzoobi et al. (2014) who studiedtheeffect of oat fiber on characteristics of sponge cake.

The color values of different treatments varied from 111.67 CTn to 148.33 CTn (Figure 1). The maximum color value was found for T_0 and minimum value was observed in case of T_4. It is apparent from results that there was a gradual decrease in color values with increasing concentrations of dried grapefruit peel powder in treatments.The change in color values may be due to addition of fiber that gives extra dark color on heating.As more fiber content will impart darker color in cake. According to Gomez et al. (2007) color of crust is associated with maillard and caramelization reactions not withthe original color of fiber, on the other hand original color of fiber influence the crumb color because caramelization reaction does not occur in crumb as temperature of crumb does not reach to as high level as temperature of crust. Lebesi and Tzia (2011) observed decrease in L value of crumb whostudiedthe effect of different dietary fibers on baking and sensory properties of cup-cakes.In another study, increase in L value of crust and decrease in L value of crumb was reported in low fat cake prepared by addition of β-glucan concentrate (Kalinga and Mishra, 2009). Increase in darkness (lower L value than control) of crust crumb color was also reported by Majzoobiet al. (2014) in oat fiber enriched sponge cake.

Effect on proximate composition of cake

Effect on moisture: The proximate compositions of fruit cakes are given in Table 2. It is confirmed from the analysis of variance that the moisture content differed highly significantly ($p>0.01$) among different treatments. Higher moisture contents were found in T_4 (23.97±1.02%) and the minimum moisture contents found in T_0 (20.57±0.30%).Moisture content increases among the treatments with addition of grapefruit albedo powder. This increase in moisture might be due to water retention property of fruit fibers (Akubor and Ishiwu, 2013; Mrabet et al., 2016).This increase in moisture level of cake was supported by finding of Lebesi and Tzia (2011) who found increase in crumb moisture by addition of dietary fiber (0 to 30%) in cupcakes. These results are also in accordance with findings of (Hassan and Ali, 2014) who found gradual increase in moisture contents among treatments in bread fortified with white grapefruit (*Citrus paradise* L.) albedo layer flour. Lim et al. (2014) found increase in moisture contents with increase in pectin percentage in cake made by replacement of fat with pectin.

Effect on crude fat: The crude fat contents also differed

Table 2: *Proximate composition of cake.*

Treatments	Moisture	Crude Fat	Crude Fiber	Crude Protein	Ash Contents	NFE
T_0	20.57±0.30c	32.55±0.20a	0.53±0.02e	13.19±0.02a	0.95±0.03e	32.21±0.23a
T_1	21.73±1.22a	31.46±0.08b	0.98±0.03d	13.01±0.04b	1.15±0.03d	31.67±0.18b
T_2	22.67±0.77ab	30.66±0.21c	1.71±0.03c	12.9±0.05c	1.55±0.06c	30.81±0.26c
T_3	23.04±0.46a	29.94±0.36d	2.01±0.04b	12.76±0.03d	1.78±0.04b	30.47±0.36d
T_4	23.97±1.02ab	28.57±0.04e	2.89±0.06a	12.57±0.03e	2.01±0.09a	29.99±0.05e

Different letters in the same column represent a significant trend. **T_0:** *Cake without grapefruit albedo powder;* **T_1:** *Cake with 1.87 g of grapefruit albedo powder;* **T_2:** *Cake with 3.75g of grapefruit albedo powder;* **T_3:** *Cake with 5.6g of grapefruit albedo powder;* **T_4:** *Cake with 8 g of grapefruit albedo powder.*

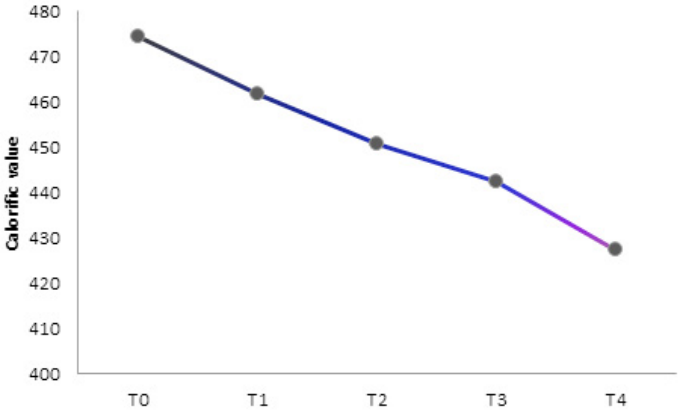

Figure 2: *Effect of different treatments on the calorific values of various fruit cakes.* **T_0:** *without grapefruit albedo flour.* **T_1:** *1.87 g of grapefruit albedo flour;* **T_2:** *3.75g of grapefruit albedo flour;* **T_3:** *5.6 g of grapefruit albedo flour;* **T_4:** *8g of grapefruit albedo flour.*

significantly among different treatments (Table 2). Highest fat contents found in T_0 (32.55±0.20%) and lowest in T_4 (28.69±0.04%). It is evident from the results that there was a gradual decrease in fat contents by addition of grapefruit peel fiber as it replaces the fat. These results are in line with findings of Alloush, (2015) who found decrease in fat contents (21.9 to 16.62%) in cake prepared with sweet potato flour with different proportions.

Effect on crude fiber: The results indicated that the fiber contents differed significantly among different treatments (Table 2). Among treatments the fiber contents ranged from 0.53±0.02 to 2.89±0.04% having highest value for T_4 and lowest value for T_0. The results showed gradual increase in fiber content by adding grapefruit peel powder in fruit cake. As grapefruit peel is a rich source of fiber so addition of grapefruit peel in powder form increases the level of fiber in treatments.

Effect on crude protein: The crude protein contents differed highly significantly among different treatments (Table 2). High protein contents were found in T_0 (13.19±0.02%) followed by T_1 and the minimum protein contents found in T_4 (12.57±0.03%). The level of protein content decreased as compared to other treatments because grapefruit fiber powder is deficient in protein. These results are in close agreement with the finding of Hassan and Ali (2014) who reported the protein content in the control was significantly higher than all other grapefruit albedo flour toasted bread. Same decreasing trend of protein contents in cake was also reported by Alloush (2015).

Effect on ash contents: The ash contents ranged from0.95±0.03 to 2.01±0.09% having highest score for $T_4$and lowest score for T_0 (Table 2). This might be due to increased ash contents of grape fruit albedo fiber than wheat flour. Our results are in line with ash contents of cake supplemented with banana peel fiber (Akubor and Ishiwu, 2013).

Effect on NFE and gross energy: It is confirmed from the results that the NFE content differed significantly among different treatments (Table 2). The lowest NFE value was observed in case of T_4 (29.99± 0.05%) and the highest was recorded in T_0 (32.21±0.23%). This is because of decrease in fat contents of cake. Decrease in carbohydrates with addition of fiber is in accordance with results of Hassan and Ali (2014) who found same trend inbread fortified with defatted grapefruit albedo flour.

It is apparent from the results as shown in Figure 2 that the gross energy differs significantly among different treatments. The lowest gross energy value was observed in case of T_4 and the highest was recorded in T_0. Aziah et al. (2011), Hassan and Ali (2014) and Alloush (2015) also reported decrease in NFE and decrease in calorie count in sweet potato based cake, grapefruit albedo flour bread and mango peel powder based cake respectively.

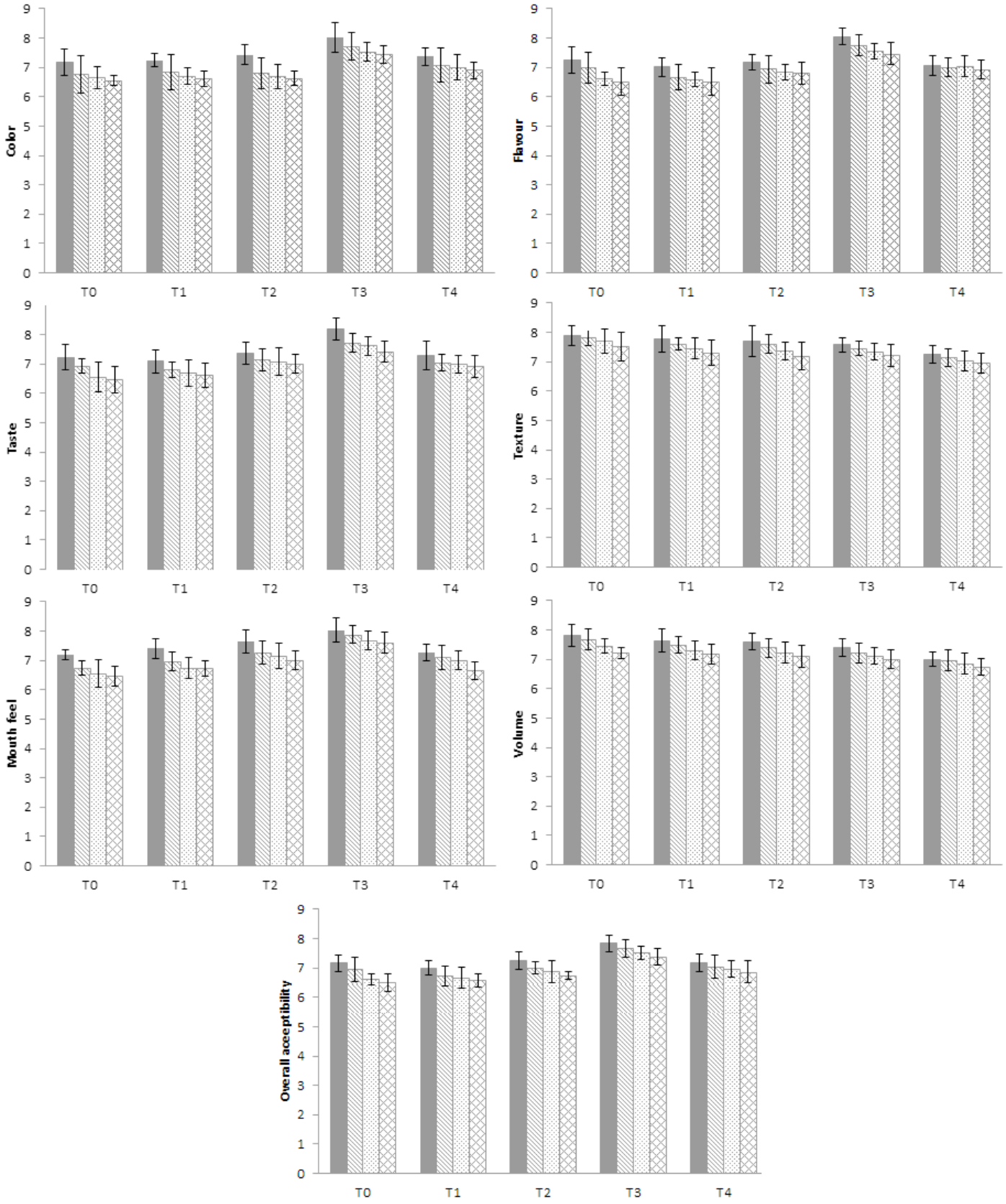

Figure 3: *Effectof different treatments on the sensory properties during 30 days storage of various fruit cakes: 0, 30 days.*
T_o: *without grapefruit albedo flour;* **T_1:** *1.87 g of grapefruit albedo flour;* **T_2:** *3.75g of grapefruit albedo flour;* **T_3:** *5.6 g of grapefruit albedo flour;* **T_4:** *8g of grapefruit albedo flour.*

Microbial analysis of cake: Bacterial and fungi count was determined in cakes during storage period of 4 weeks. The TPC of fruit cake are shown in Table 3. Results showed that the TPC varied highly significantly ($p \leq 0.01$) among different treatments. The highest count was observed in case of T_4 ($2.19 \pm 1.31 Log_{10}$ cfu/g) at 0 day and 2.97 ± 1.25 Log_{10} cfu/g at 30 day of storage. Lowest count was ob-

served in T_0 (1.09 ±1.10e Log_{10} cfu/g) at 0 day and 2.25±1.40 at 30 day of storage. This change in bacterial count among treatments might be due to increase in moisture contents with increase in fiber addition. The results showed that the Mold/Yeast growth varied significantly among different treatments. At 0 day yeast and mold count was zero because of high baking temperature. At 30 day of storage yeast and mold count was in range of 1.87±1.36 to 2.02±1.42 Log_{10}cfu/g. The count of different treatments ranged from 0.93 to 1.01 Log_{10}cfu/g having highest score in T4 and lowest score in T_0 (0.93 Log_{10} cfu/g). Morkos et al. (2013) studied the bacterial and fungi count in butter cake prepared with peanut and chick pea. They found increase in microbial count during storage period of four weeks. Our findings are also in line with findings of Agu and Okoli (2014) who reported zero mold count at 4 day storage of biscuits and increase in total microbial count was observed in biscuits during 20 days of storage.

Effect on sensory parameters of cake: All treatments obtained acceptable scores but T_3 was preferred by the judges in term of color (8.02±0.50), flavor (8.04±0.29), taste (8.18±0.37), mouth feel (8.03±0.41) and overall acceptability (7.84±0.28) followed by T_2 even after storage period of 30 days (Figure 3).

Table 3: *Effect of different treatments on total plate count and mold count (log10cfu/g) of fruit cake.*

Treatment	Total Plate Count		Yeast and Mold	
	0	30	0	30
T0	1.09±1.10e	2.25±1.40e	Nil	1.87±1.36d
T1	1.13±1.52d	2.29±1.08d	Nil	1.93±1.54c
T2	1.15±1.47c	2.32±1.54c	Nil	1.98±1.12b
T3	1.16±1.20b	2.34±1.41b	Nil	1.99±1.50b
T4	2.19±1.31a	2.97±1.25a	Nil	2.02±1.42a

Different letters in the same column represent a significant trend. **T_0:** *Cake without grapefruit albedo powder;* **T_1:** *Cake with 1.87 g of grapefruit albedo powder;* **T_2:** *Cake with 3.75g of grapefruit albedo powder;* **T_3:** *Cake with 5.6g of grapefruit albedo powder;* **T_4:** *Cake with*

In case of texture and volume, T_0 gained highest marks 7.90±0.34 and 7.82±0.37 respectively, followed by T_1, T_2, T_3 and T_4. Replacement of fat with fiber increased the hardness of cake and T_4 gained lowest marks in term of texture (7.24±0.31) and volume (7.0±0.25) of cake but these were also in acceptable range. Fiber hinders in release of water and cause reduction in the aeration of the cake batter which cause decrease in volume. This reduced volume affects the texture of cake negatively. Our findings of sensory attributes of cake are in accordance with findings of Mrabetet al. (2016) who reported sensory attributes of muffins enriched with date fruit fiber. According to them enrichment of fiber in muffin is acceptable upto a limit after that fiber enriched product got lower marks by panelist. But average results showed that all the treatment had good scores, between 6 and 8 on a 9-point scale. Incorporation of grapefruit albedo fiber in bread recorded scores in range of 7 to 9. Majzoobi et al. (2015) reported that addition of oat fiber in sponge cake up to 20% was acceptable by panelist in regards of all sensory attributes but panelists noted slightly bitter after taste and darker color when 30% oat fiber was used in cake.

Acknowledgement

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Authors' Contributions

Aneela Qureshi: She has developed fruit cake. Ammara Ainee, Muhammad Nadeem: Provided the research design. Masooma Munir, Tahir Mahmood Qureshi: They have participated in research analysis and drafted the paper. Saqib Jabbar: Analyzed the data statistically and final reviewed of the manuscript.

Conclusion

Grapefruit albedo is a good source of fiber.Up to 8% grapefruit fiber can be replaced with fat without any considerable change in sensory properties. Fat replacement may not only be beneficial for human health but would also a source of profit for industry.

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