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Research Article

Utilization of citrus plant waste (peel) for the development of food product

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Abstract

Citrus peels, the waste by-products of citrus juices factories are valuable healthful functional food (fiber, mineral and antioxidants). The present investigation performed to assess the nutritional status of fortified cake with *citrus sinensis* (sweet orange) peels powders. Citrus peel and fine flour contains moisture 7.62%, 9.82%, protein 4.53%, 10.55%, fat 3.82%, 1.52%, fiber 63.45%, 1.77% and ash 4.63%, 4.14%. Different level of orange peel from 1% - 5% were blended with wheat flour to produce composite flour. Ash content increased from 1.00 to 2.00%, Moisture showed reduction from 24.32% (T0) to15.96%(T5), Crude protein was reduced from 12.00%(T0) to 11.02%(T5), crude fat content increased from 13.05%(T0) to 15.34%(T5), and crude fiber increased from 2.00%(T0) to 6.46%(T5). Citrus peel cakes were found reasonably different just as subjected to organoleptic analysis. Mean values for color T0 (7.20)-T5 (6.33), taste, T0 (7.13)-T5 (6.14), texture T0 (7.23)-T5 (6.54), overall acceptability T0 (7.19)-T5 (6.34). From the current results it is concluded that blending of wheat flour up to 3% citrus peel flour is suitable for cake development with acceptable sensory attributes and the addition of peel powder in cake increases its nutritional and functional attributes.

Keywords: Citrus peel; Citrus peel fortified cake; Organoleptic attributes; Proximate constituents; Wheat flour

Introduction

Citrus is the most abundant in the earth; with orange, grapefruit, lemon are the most regular citrus fruits **[1]**. World's production of citrus is 115.52 million tons, and in Pakistan it is resided at the area of 199,000 hectares with total production of 2007.0 thousand tones in Pakistan **[2]**. Citrus is consist of two separate regions the endocarp and the pericarp, the pericarp is consist of peel that contain large number of aromatic oil glands, which gives a particular smell and gloss **[3]**. The mass of peel is 50-60 % to the total mass of citrus fruit that is disposed of as waste martial after processing, which can be converted in to value added products or fortified with food products to increase the nutritional profile **[1]**. If this waste is not utilized this can cause fabricate bad smell,

soil contamination, harborage for insects and causes severe pollution of environment [3].
A large part of this production is use for juice extraction of citrus in the industries leaving at the back massive amounts of remaining waste containing peel and segment membranes. Peels cover of about 50 to 60% of total weight of fruits and left as the most important by product [4].
The phytochemicals including vitamins, cumarins, terpenoids, flavonoids, carotenoids, lignin are present in plant material and plant material have high anti-oxidant activity due to the existence of these phytochemicals [5]. As citrus peel comprises the phenolic and phlavonoids composite, it hold high anti-oxidant activity. Bioactive composition including anti-oxidants such as ascorbic acid, phenolic compounds, flavonoids and pectins are found in citrus fruits and juices that are essential to human nutrition [6].
Cakes have high importance in bakery due to its taste, texture, flavors and variety of brands present in the market. Recently cereal industry has global market increment with about 1.5 % a year. Cake market having challenges of cost, shelf life and quality attributes [7]. Mostly cake is taken preference from bread and other cereal products due its soft texture and good mouth feel characters. Mostly peoples consume cake because it is a quick source of energy [8].
The major by products from citrus processing is its peel. Citrus peel represents 50-60% of the total weight of the fruit. The citrus juice industry uses only the pulp portion of the citrus and a considerable amount of peel is discarded as industrial waste. The large amount of waste produced by the food industries causes serious environmental problems and also results in economic losses if not utilized effectively, because it is a substrate for the growth of different pathogen. Although , peel has high nutraceutical value so that it can be used as functional ingredient in form of citrus peel powder for the benefits of pharmaceutical, food and cosmetic industries for health promoting effect which is of vital importance, this way we can utilize the peel waste and protect our environment from pollution created due to waste of citrus peel. Because the citrus especially its peel portion is a source of significant anti-oxidants so its inclusion in the cakes was attempts to develop a cake with improved antioxidant activity along with additional nutrients which was the plan of the current study. Consequently, the plan of this study was to estimate the sensory profile and preference mapping of cakes supplemented with citrus peel.

Materials and methods

Materials

The materials used in the investigation were wheat flour, sodium chloride, soybean oil, fresh eggs, baking powder, Sugar were purchased from the local market of Peshawar City. Citrus peel were collected from District Battagram; KPK, and transported to FST (food science and technology) Lab of Agriculture University Peshawar.

Processing of cake

The cake formula in this study was adapted from the work of [9]. The formula of cakes at six different citrus peel powder levels is shown below in table 1.

Preparation of citrus peel powder

Citrus peel were removed from citrus, then the peel were boiled in water (1:4 peels: water) for about 10 minutes and then put in an oven at a temperature of 70^{o}C for 24 hours. After drying the peels were ground to flour to a particle size of less than 0.2 mm, then citrus peel powder were packed in poly ethylene bags and stored for further use [10].

Preparation of cake

Citrus peel powder were infused with boiling water for 5 min in a bowl and cooled to 24–26^{o}C. Whole egg and egg yolk were poured into a bowl, and mixed by hand with an

eggbeater. Sweetener and sodium chloride were added to the bowl, and then warmed to 40°C over a hot water bath. Ingredients were mixed by hand with a plastic scraper until smooth. The cake butter was immediately deposited into cake pans. For each cake, 250g of mixture were poured into a cake pan (20.3 cm in diameter 7 cm in height) and baked at 160°C for 40 min in a preheated oven (30mins) (Table 2). The cakes were allowed to cool for 2 hours, and then were removed from the pans. The cooled cakes were packed in polypropylene bags at room temperature before physicochemical and organoleptic analyses [11].

Table 1. Treatment Combinations

S. No	Treatments	Cake flour %	Citrus Peel Powder %
1	**T0**	100 %	0 %
2	**T1**	99 %	1 %
3	**T2**	98 %	2 %
4	**T3**	97 %	3 %
5	**T4**	96 %	4 %
6	**T5**	95 %	5 %

Control T0 (100% wheat flour, 0% peel powder), T1 (99% wheat flour, 1% peel powder), T2 (98% wheat flour, 2% peel powder), T3 (97% wheat flour, 3% peel powder), T4 (96% wheat flour, 4% peel powder), T5 (95% wheat flour, 5% peel powder)

Table 2. Formulation of cakes

S. No	Ingredient (g)	Control	T1	T2	T3	T4	T5
1	**Cake flour**	190	187.5	185	182.5	180	177.5
2	**OP Powder**	0	2.5	5	7.5	10	12.5
3	**Sugar**	258	258	258	258	258	258
4	**Whole egg**	258	258	258	258	258	258
5	**Egg yolk**	57	57	57	57	57	57
6	**Salt**	3	3	3	3	3	3
7	**Soybean oil (ml)**	38	38	38	38	38	38
8	**Water (ml)**	84	84	84	84	84	84

Control T0 (100% wheat flour, 0% peel powder), T1 (99% wheat flour, 1% peel powder), T2 (98% wheat flour, 2% peel powder), T3 (97% wheat flour, 3% peel powder), T4 (96% wheat flour, 4% peel powder), T5 (95% wheat flour, 5% peel powder)

Chemical analysis

Moisture contents were determined at (Model: 605, Precision Oven, Thermo Fisher Scientific) 105°C till constant weight, ash contents were determined by drying the sample and then placed in muffle furnance (muffle furnace, lef-2055-0, Daihan Labtech, Korea) at 550°C, crude fat contents were estimated by using soxhlet apparatus us diethyl ether as solvent, crude fiber contents were determined by digesting the moisture and fat free samples with both acid (1.25% sulphuric acid) and alkali solution (1.25% sodium hydroxide solution), crude protein contents were estimated by using Kjeltech apparatus, sulphuric acid and digestion mixture of copper sulphate, iron sulphate and potassium sulphate for digestion process and after distillation the sample is titrated against 0.25 N sulphuric acid (Kjel Tech apparatus) were measured **[12].**

Organoleptic analysis

Samples of the cake were evaluated for color, taste, flavor and overall acceptability by a

panel of ten judges. The evaluation was carried out by using 9 points hedonic scale [12].

Statistical analysis

Data were analyzed by using one way analysis of ANOVA (analysis of variance) and means were compared by applying LSD (Latin square design) at alpha 0.05 [13].

Results and discussion

Chemical analysis of wheat flour and citrus peel flour

Raw ingredients including wheat flour and citrus peels flour were analyzed for proximate composition (moisture, crude protein, crude fat, crude fiber and ash content) and data obtained is shown in table 3. The result for proximate composition of citrus peel flour was carried out and shows moisture (7.62%), crude protein (4.53%), crude fat (3.82%), crude fiber (63.45%) and ash (4.63%). The data obtained were shown very close association with [14], [15], [16]. Proximate composition of wheat flour was obtained as moisture content (9.82%), crude protein (10.55%), crude fat (1.52%), crude fiber (1.77%) and ash content (4.14%). The results were in agreement with the investigation of [17], [18]. *Citrus sinensis* peel is a good source of fiber and fat as compare to wheat flour, if we incorporate citrus peel with wheat flour as an additional ingredient for cake preparation it can produce dynamic effect on cake by increasing the nutritional value, functional properties and overall acceptance of the product.

Table 3. Proximate contents of citrus peel powder and wheat flour

Sample type	Moisture %	Protein %	Fat %	Fiber %	Ash %
Citrus peel	7.62% ± 0.12	4.53% ± 0.11	3.82% ± 0.09	63.4% ± 1.62	4.63% ± 0.08
Wheat flour	9.82% ± 0.15	10.5% ± 0.18	1.52% ± 0.03	1.77% ± 0.03	4.14% ± 0.09

Mean of three replications with standard error

Proximate analysis of cake fortified with citrus peel

Analysis of variance showed that the treatments have momentous effect ($p<0.05$) on ash, moisture, protein, fat and fiber contents of cake citrus peel (Table 4). Treatments showed increasing trend on ash percentage of cake. Means values of Ash content of citrus peel cake for T0 were (1.00%), T1 (1.25%), T2 (1.31%), T3 (1.40%), T4 (1.59%) and T5 (2.00%). The maximum mean value of ash (2.00%) was noted in T5 while the minimum mean value (1.00%) was noted in T0. The addition of citrus peel up to 4% has not effect too much on ash content while 5% peel addition increased the level of ash content more than the other samples T0, T1, T2, T3 and T4. These findings were in agreement with the work of [6, 19]. The *citrus sinensis* peels addition up to 5% showed significant different from other levels of citrus peels.

Moisture content of citrus peel cake decreased with increasing the addition of citrus peel, means values for moisture content of citrus peel cake were T0 (24.32%), T1(19.80%), T2 (18.11%), T3 (17.45%), T4 (16.76%) and T5 (15.96%). The highest mean value (24.32%) was recorded in T0 and the minimum mean value (15.96%) was recorded in T5. The moisture content of the cake were seen to be decreased as the level of citrus peel increased. These results were closely related with the work of [19, 20]. The moisture content of the citrus peel was found to be less than the wheat that may be the reason of decreasing level of moisture in the cake.

Analysis of variance showed that treatment has pronounced effect on the protein content of citrus peel cake. The mean values for protein content of citrus peel cake were T0 (12.00%), T1 (11.50%), T2 (11.38%), T3 (11.34%), T4 (11.16%) and T5 (11.02%).

The highest mean value (12.00%) was recorded in T0 while the minimum mean value (11.02%) was recorded in T5. All the other treatments were significantly different ($p<0.05$) from the control. The reason of decreasing the level of protein content could be the level of protein content was low in citrus peel flour than wheat flour. Similar pattern was also shown by **[19-22]**.

Table 4. Effect of citrus peels flour on proximate composition of cake

Treatments	Ash %	Moisture %	Protein %	Fat %	Fiber %
T0	1.00 e ± 0.02	24.32 a ± 0.83	12.00 a ± 0.61	13.05 d ± 0.71	2.00 f ± 0.02
T1	1.25 d ± 0.02	19.80 b ± 0.52	11.50 b ± 0.72	13.50 cd ± 0.60	2.89 e ± 0.01
T2	1.31 d ± 0.02	18.11 c ± 0.51	11.38 c ± 0.84	13.96 bcd ± 052	3.78 d ± 0.04
T3	1.40 c ± 0.03	17.45 d ± 0.60	11.34 c ± 0.79	14.42 bc ± 0.56	4.60 c ± 0.03
T4	1.59 b ± 0.03	16.76 e ± 0.75	11.16 d ± 0.67	14.80 ab ± 0.51	5.55 b ± 0.04
T5	2.00 a ± 0.02	15.96 f ± 0.68	11.02 e ± 0.73	15.34 a ± 0.62	6.46 a ± 0.05

Mean of three replication with standard error.
T0 (100% wheat flour, 0% peel powder), T1 (99% wheat flour, 1% peel powder), T2 (98% wheat flour, 2% peel powder), T3 (97% wheat flour, 3% peel powder), T4 (96% wheat flour, 4% peel powder), T5 (95% wheat flour, 5% peel powder)

Treatments showed moderately increasing trend on fat percentage of cake. The means fat content of citrus peel cake were T0 (13.05%), T1 (13.50%), T2 (13.96%), T3 (14.42%), T4 (14.80%) and T5 (15.34%). The minimum mean value (13.05%) was recorded in control that increase up to (15.34%) in T5. The addition of citrus peel up to 4% has not effect too much on crude fat content while 5% peel addition increased the level of crude fat content more than the other samples. T5 showed significantly different ($p<0.05$) from all other treatments as compared with the control. This increasing pattern was also found in the work of **[20-22]**. The fat content observed to be more in citrus peel flour than wheat flour, which could be the reason of increment found in crude fat content.

Mean values for crude fiber content of citrus peel cake were T0 (2.00%), T1 (2.89%), T2 (3.78%), T3 (4.60%), T4 (5.55%) and T5 (6.46%). The highest mean value (6.46%) was recorded in T5 while minimum mean value was noted in T0 (2.00%). The reason of increasing trend observed in the crude fiber content of the cake could be the fiber content was observed to be more in citrus peel flour than wheat flour. The similar pattern was observed and indicates a similar increasing trend in fiber level of cake in the work of **[20-22]**.

Organoleptic analysis

The citrus peel cake analyzed for color, taste, texture and overall acceptability. The sensory analysis was carried out through Larmond scale (hedonic 9-points) by 10 judge's panel. These evaluations are as under **[12]**.

The statistical results revealed that treatments had a notable effect ($p<0.05$) on color, taste, texture and overall acceptability of citrus peel cake (Table 5). The Mean score of color for different treatments were T0 (7.20), T1 (7.12), T2 (7.08), T3 (7.18), T4 (6.83) and T5

(6.33). T0 (7.20) showed maximum increment while the minimum mean occur in T5 (6.33). The results showed that up to 3% level of citrus peel addition has non significantly different from the control observed by the panelist. While the addition of 4 and 5% secured less score from the penelists. This may be due to the presence of poly phenols in the citrus peel which give the darker color to the cake [21]. The cake samples were sensory evaluated the judges of the sensory panelists on hedonic scale. The results were closely related to the work of [19], [22]. So the citrus peel up to 3% addition in cake declared as acceptable by the sensory panelists.

Mean score of taste for different treatments were T0 (7.13), T1 (6.75), T2 (6.82), T3 (6.82), T4 (6.31) and T5 (6.14). Maximum mean score for taste (7.13) was shown in T0 while minimum mean score was shown in T5 (6.14). The addition of citrus peel with 1, 2, 3, 4 and 5% level in cake has non-significant ($p<0.05$) effect on taste of cake. the addition of the peel gives bitter taste to the product as reported by [19] All the samples having citrus peels were neither like nor dislike in the taste quality which means citrus peel addition lies in acceptable range on hedonic scale. So it can be concluded that the addition of citrus peels up to 3% in cake was found to be acceptable like control sample because it is near in score to control sample. The results were closely related to the work of [19, 21].

Table 5. Organoleptic analysis of cake fortified with citrus peel

Treatments	Color	Taste	Texture	Overall Acceptability
T0	7.20 a ± 0.04	7.13 a ± 0.05	7.23 a ± 0.04	7.19 a ± 0.04
T1	7.12 a ± 0.05	6. 75 b ± 0.04	6.99 b ± 0.03	6.95 c ± 0.03
T2	7.08 a ± 0.03	6.82 b ± 0.03	7.05 ab ± 0.04	7.98 bc ± 0.05
T3	7.18 a ± 0.03	6.82 b ± 0.04	7.14 ab ± 0.03	7.05 b ± 0.05
T4	6.83 b ± 0.04	6.31 c ± 0.03	6.77 c ± 0.04	6.64 d ± 0.04
T5	6.33 c ± 0.05	6.14 d ± 0.05	6.54 d ± 0.05	6.34 e ± 0.03

Mean of three replication with standard error.

0 (100% wheat flour, 0% peel powder), T1 (99% wheat flour, 1% peel powder), T2 (98% wheat flour, 2% peel powder), T3 (97% wheat flour, 3% peel powder), T4 (96% wheat flour, 4% peel powder), T5 (95% wheat flour, 5% peel powder)

Mean score of texture for different treatments were T0 (7.23), T1 (6.99), T2 (7.05), T3 (7.14), T4 (6.77) and T5 (6.54). Maximum increase showed in T0 (7.23) followed by T3 (7.14) while minimum increase occurred in T5 (6.54). It was observed that citrus peel in the cake did not showed significant difference ($p<0.05$). But the addition of 3% is much closer to the control and showed that the cake improved in its texture quality as its mean is statistically different from all other treatments. So this result proved that the addition of citrus peel up to 3% improved the texture of cake and acceptable in the texture characteristics. The score in the range 7 to 7.9 means that the judges like the sample having 3% citrus peels at moderate level on hedonic scale. The results were closely related to the work of [21, 22].

Analysis of variance showed that treatments had a remarkable effect on overall acceptability of citrus peel cake. Mean score for treatment were T0 (7.19), T1 (6.95), T2 (6.98), T3 (7.05), T4 (6.64) and T5 (6.34). Maximum mean value was showed in T0 (7.19) followed by T3 (7.05) while minimum mean value occur in T5 (6.34). Among the different level of citrus peel it was noticed

that the judges gave the maximum score to the sample T3 that is (7.05) this means that it is slightly liked by the judges of the panelists. So it is concluded that the addition of citrus peel in the cake was found to be acceptable on the basis of overall acceptability up to 3% citrus peel addition. These results were closely related to the findings of **[19, 21]**.

Conclusion

From the current results it is concluded that blending of wheat flour up to 3% citrus peel flour is suitable for cake development with acceptable sensory attributes. It is assumed from the study that blending of fine flour with citrus peel powder could develop appreciable quality cake containing high nutritious value. Addition of citrus peel, the chemical nature of citrus peel cake, Crude fat, crude fiber and ash contents increased whereas moisture and crude protein content reduced. Organoleptic attributes of citrus peel cake like color, taste, texture and overall acceptability were varied remarkably but within acceptable range. Further research work should be done to determine the influence of packaging and nutritional quality of citrus peel cake. There should be further work needed on preparation of nutritious baked products blended with citrus peel with other cereals. It is recommended that addition up to 3% citrus peel flour is acceptable in the cake.

Authors' contributions

Conceived and designed the experiments: M Iftikhar & S Wahab, Performed the experiments: M Iftikhar, Analyzed the data: NU Taran & NU Haq, Contributed materials/ analysis/ tools: SN Malik & S Amber, Wrote the paper: SU Rehman.

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