J. Agr. Sci. Tech. (2013) Vol. 15: 1175-1184

The Effect of Particle Size and Level of Rice Bran on the Batter and Sponge Cake Properties

M. Majzoobi[1*], S. Sharifi[1], B. Imani[1], and A. Farahnaky[1]

ABSTRACT

Rice bran is a major by-product of the rice milling process that contains high amounts of fiber, proteins, fats, vitamins, minerals as well as antioxidants and hence can be utilized in enriching food products. The main aim followed in this study was to determine the effects of rice bran of variable particle sizes (53, 125 and 210 µm) and its quantity (0, 5, 10, 15 and 20%) on the quality of batter and on sponge cake. Increasing bran quantity and particle size increased batter density and consistency. Using a higher quantity of bran with larger particle sizes increased cake density and weight of the cakes (after being baked) while decreasing the cake volume. Textural properties of the samples as determined instrumentally showed that maximum compressive force and the firmness increased, while cohesiveness and springiness decreased with increase in the contents of bran and increase in its particle size. Cake crust color became darker, more reddish and less yellowish with inclusion of rice bran. Increasing the levels of rice bran, negatively affected taste, crust and crumb color as confirmed by the sensory panel. Overall, it was found that addition of 10% rice bran with particle size of 125 µm resulted in the most desirable cake quality.

Keywords: Particle size, Physical properties, Rice bran, Sponge cake, Textural properties.

INTRODUCTION

There is a growing interest towards the consumption of high fiber foods, since the health benefits of these products have been well established. Nevertheless, manufacture of such products is challenging since increasing the fiber content usually shows adverse effects on the product quality and consequently on the consumer acceptance. Therefore, food manufacturers are looking forward to find fiber rich recipes with the least negative effects on the quality of the final product. Cereal bran is a rich and cheap source of dietary fiber, produced as a by-product during the milling process of grains. Bran is also rich in proteins, fat, vitamins, minerals and antioxidants. Taking into account the benefits of cereal bran, it has been utilized in increasing the fiber content of different foods. Amongst these foods, bread and other bakery products are of great interest, since they are among the highly consumed ones. Previous studies have documented the inclusion of wheat and oat bran in bread making (Krishnan *et al.,* 1987; Wang *et al.,* 2002), fibers from different cereal sources on the quality of dough and biscuits (Sudha *et al.,* 2007), whole grain flours from rye, triticale, hull-less barley and tritordeum to elaborate layer cakes (Gomez *et al.,* 2010b), and as well the use of wheat, oat, barley and rice brans in the production of different types of cakes (Gomez *et al.,* 2010a; Lebesi and Tzia, 2011). Amongst cereal brans, rice bran is produced in large quantities in Asian countries since milled rice is taken as a staple food in these states. Rice bran contains about 45-50% total, 37-40% insoluble and 9-10% soluble dietary fiber, 14-15% protein and 18-20% fat

[1] Department of Food Science and Technology, Shiraz University, Shiraz, Islamic Republic of Iran.
[*] Corresponding author; e-mail: majzoobi@shirazu.ac.ir

(Saunders, 1990; Lebesi and Tzia, 2011). Rice bran oil is a rich source of antioxidants. It has cholesterol lowering properties, and as well, anti-atherogenic activity (Cicero and Derosa, 2005; Wilson *et al.,* 2002). Despite the nutritional value of rice bran, it is largely used as animal feed and is an underutilized resource of value-added products.

The main objective followed in this study was to utilize rice bran in the production of sponge cake and to determine the most appropriate level and particle size of the bran that would result in acceptable cake technological and sensory qualities.

MATERIALS AND METHODS

Materials

Wheat flour utilized, contained 11.50±0.30% moisture, 9.35±0.40% protein (N×5.7), 0.43±0.20% fat, 0.52±0.10% ash and 78.20±0.30% total carbohydrates, all determined according to the Approved Methods of the AACC (2000). Sugar, sunflower oil, whole fresh eggs, semi-skimmed fresh milk, vanilla and baking powder (containing sodium bicarbonate, tartaric acid and cornstarch) were purchased from the local market. Whole fat rice bran was supplied by a local rice milling factory in Zarghan, Fars, Iran. The bran was packed in polyethylene bags and kept in at -18 °C for further experiments. To obtain different particle size rice bran, it was milled by means of a laboratory mill (Alexander Werck, Model WEL82, Germany) and then manually sieved, to obtain the average particle sizes of 53, 125 and 210 µm.

Methods

Cake Formulation

Control cake sample was made up of 250 g flour, 200 g milk, 125 g corn oil, 180 g sugar, 100 g of eggs, 10 g baking powder and 1 g of vanilla. To prepare batters containing rice bran, flour was replaced with bran at different levels (0, 5, 10, 15 and 20%, w/w, flour basis) for each particle size.

Batter Preparation

Cake batter was prepared by means of a kitchen cake mixer (Moulinex, Model HM 1010, Beijing, China) using sponge cake method in which eggs, vanilla and sugar were mixed together until a semi-firm foam obtained. Fresh milk was added to the foam and after that, flour which contained bran and baking powder was mixed with the other ingredients. At the end, corn oil was slowly added to the cake batter.

Determination of Batter Density

Batter density was measured as described by Gomez *et al.* (2007) by obtaining the ratio of the weight of a standard container filled with batter to that of the same container filled with distilled water (density of 1 g cm^{-3}).

Determination of the Batter Bostwick Number

One hundred g of the batter at ambient temperature (20±0.5ºC) was poured in the reservoir of a Bostwick consistometer and left for 2 min and then the moving distance by the batter (cm) and during 15 seconds was determined. The higher Bostwick number corresponds to the lower batter consistency (Majzoobi *et al.,* 2012).

Baking of the Cakes

To bake cakes, 150 g of batter was poured into aluminum pans (18×9×8 cm) and baked at 180º C in an electrical oven (Karl Welkerkg, Venusbergstr, Germany) for about 45 minutes. Pans were removed from oven and baked cakes cooled at room temperature for 1 hour. They were sealed in polyethylene bags and kept at ambient temperature for further experiments which were completed by next day (within approximately 24 hours).

General Characteristics of the Cakes

Moisture of the cakes was determined by oven drying at 105°C until a constant weight was reached. Cake volume was measured by rapeseed displacement method according to the Approved Methods of the AACC (2000). Baking loss was determined by dividing the difference between the weight of batter and that of the cake to the weight of the batter.

Textural Properties of the Cakes

Textural characteristics of the cakes were assessed by means of a texture Analyzer (TA-XT2, Stable Micro Systems Ltd., Surrey, UK). Texture Profile Analysis (TPA) test was performed through two bite compression test before which 1 cm of the crust was removed to make the surface leveled off. TPA was done at pretest speed of 5 mm s^{-1}, test speed of 0.25 mm s^{-1}, time interval of 10 seconds and strain deformation of 25% through an aluminum cylindrical probe of a diameter of 75 mm. Hardness of texture was obtained from a maximum force of the first bite of TPA test (F1); the ratio of areas (A_2/A_1) from force-distance curves indicated cohesiveness, springiness being determined by dividing the second peak time by the first peak time (t_2/t_1), and the gradient being the slope of the first bite of TPA test and the indicated firmness (Steffe, 1996).

Color of the Cakes

The color parameters of L (lightness), a (greenness-redness) and b (blueness-yellowness) values of the cake crust and crumb were assessed according to Afshari-Jouibari and Farahnaky (2011). Crust and crumb color of the cakes were evaluated by taking images (using a digital camera Finepix, Model JZ300, Beijing, China) of each sample, separately. Resolution, contrast and lightness of the images were set at 300 (dpi), 60 and 60%, respectively. To determine crust color, pictures were taken from the whole crust while to determine the crumb color, samples were sliced horizontally from the middle of the cakes following which pictures were taken. The pictures were later saved in JPEG format and analyzed by use of the Adobe Photoshop C55.1 software and color parameters were obtained.

Sensory Characteristics of the Cakes

Sensory analysis of the samples was carried out through a judgment of 10 semi-trained panelists (5 males and 5 females) each between 20 to 30 years of age. Panelists were graduate students and staff members of the laboratory, familiar with sensory tests. A series of preliminary trials were performed before the actual sensory evaluation test during which the panelists were made familiar with how to evaluate cake characteristics. To avoid panelists from being confused (as a result of too many samples to test) sensory evaluation was done in two session; in the first section the effect of particle size (using cakes with 10% rice bran but of different particle sizes) and in the second session the effect of bran quantity (using cakes with 5-20% rice bran at constant particle size of 125 μm) were tested. Panelists were asked to compare the samples and evaluate crust and crumb color, texture, flavor, taste as well as the overall acceptance, using a 5-point hedonic scale (1= Very disliked, 5= Very liked). The samples were placed on white plates and coded with a random three-digit number. Experiments were done in isolated booths under day light illumination, constant air temperature (22±2°C) (Stone and Sidel, 2004).

Statistical Analysis

The experiments were performed in a completely randomized design, conducted in triplicates with the mean values as well as standard deviations calculated. Analysis of Variance (ANOVA) was performed with the results divided apart using Multiple Ranges Duncan's Test (α< 0.05) and employing statistical software SAS version 9.1 for Windows.

RESULTS AND DISCUSSION

Batter Properties

The effects of quantity and particle size of rice bran on batter characteristics are shown in the Table 1. Increasing bran quantity and particle size increased batter density from 1.11 to 1.22 g cm^{-3} and while decreasing the batter Bostwick number from 7.15 to 5.00 cm. The results are in agreement with Allais *et al.* (2006) and Gomez *et al.* (2010a, b). Density of the batter is negatively affected by the air bubbles introduced into the batter during mixing (Gomez *et al.,* 2008; Tan *et al.,* 2011). The captured air in the batter is the determining factor, since it is related to the final volume and texture of the cakes (Campbell and Mougeot, 1999).

Decrease in batter Bostwick number (increase in batter consistency) may be related to the high potential of the rice bran hydrocolloids, such as proteins, starch and non-starch polysaccharides to absorb water and thicken the batter (Rosell et al 2001; Ayadi *et al.,* 2009; Lu *et al.,* 2010). Allais *et al.* (2006) have indicated that the incorporation of air into batter modifies its viscosity. If the consistency is too low, the air bubbles in the batter rise to the surface and are lost to the atmosphere. On the other hand, a very high consistency may retain bubbles in the batter, but it may also restrict expansion during baking. Larger particle sizes of the bran can interfere with batter homogeneity and increase batter consistency. It is also possible that the aggregation of rice bran proteins through disulfide bond cross-linking together with the increase in water retention result in higher batter consistency. According to Gomez *et al.* (2007) batters of low consistency may not be able to retain air bubbles, exerting negative effects on the final volume of the cakes. Moreover, a high consistency of the batter may prevent a sufficient release of CO_2 during baking causing a limited expansion of the cakes.

Cake Properties

As observed from Table 2, cake density increased while its volume being decreased with increase in bran concentration and particle size. The results of this study are in agreement with those reported by Lu *et al.*

Table 1. Density and Bostwick number of the cake batter containing different levels and different particle sizes of rice bran.

Particle size(μm)	Bran level (%) 0	5	10	15	20
	Density (g cm^{-3})				
53	1.11±0.01^{h}	1.12±0.01^{g}	1.13±0.01^{f}	1.17±0.01^{dc}	1.20±0.01^{b}
125	1.11±0.01^{h}	1.13±0.01^{f}	1.15±0.01^{e}	1.18±0.01^{c}	1.21±0.01^{ab}
210	1.11±0.01^{h}	1.15±0.01^{e}	1.16±0.01^{de}	1.21±0.01^{ab}	1.22±0.02^{a}
	Bostwick number (cm)				
53	7.15±0.60^{a}	6.47±0.10^{b}	5.90±0.10^{cd}	5.80±0.08^{cd}	5.30±0.08^{e}
125	7.15±0.60^{a}	6.00±0.18^{c}	5.60±0.08^{d}	5.50±0.18^{d}	5.00±0.18^{f}
210	7.15±0.60^{a}	5.70±0.08^{cd}	5.60±0.08^{d}	5.40±0.08^{e}	5.10±0.16^{f}

Values are the average of triplicates±standard deviation. For each characteristic, data followed by different letters are significantly (P< 0.05) different.

Table 2. Physical characteristics of cakes containing different levels and different particle sizes of rice bran.

	Bran level (%)				
Particle size (µm)	0	5	10	15	20
			Density (g cm^{-3})		
53	0.36±0.01^{c}	0.37±0.01^{c}	0.37±0.01^{c}	0.38±0.01^{c}	0.38±0.02^{c}
125	0.36±010^{c}	0.39±0.02^{bc}	0.34±0.00^{d}	0.40±0.03^{bc}	0.42±0.02^{bc}
210	0.36±010^{c}	0.40±0.00^{bc}	0.41±0.02^{bc}	0.43±0.01^{bc}	0.46±0.07^{a}
			Volume (cm^{3})		
53	334.5±0.6^{a}	327.1±0.5^{b}	326.8±0.9^{b}	322.9±0.9^{c}	323.1±0.3^{c}
125	334.5±0.6^{a}	318.7±0.7^{d}	306.2±0.7^{f}	301.4±0.8^{g}	296.4±0.6^{i}
210	334.5±0.6^{a}	309.2±1.0^{e}	299.0±0.4^{h}	296.8±0.6^{i}	270.3±1.4^{j}
			Weight (g)		
53	119.57±1.09^{c}	119.89±0.48^{c}	120.70±0.86^{c}	121.21±0.91^{cb}	122.76±0.78^{b}
125	119.57±1.09^{c}	120.60±0.41^{c}	121.26±0.68^{cb}	121.66±0.77^{cb}	122.76±0.46^{b}
210	119.57±1.09^{c}	121.37±0.99^{cb}	122.01±0.41^{b}	122.30±0.63^{b}	124.27±1.36^{a}
			Baking loss (%)		
53	20.23±0.74^{a}	20.03±0.33^{ab}	19.53±0.59^{b}	19.15±0.59^{b}	18.10±0.48^{c}
125	20.23±0.74^{a}	19.58±0.49^{b}	19.20±0.37^{b}	18.58±0.51^{c}	18.05±0.40^{c}
210	20.23±0.74^{a}	19.05±0.70^{b}	18.55±0.25^{c}	18.43±0.39^{c}	17.10±0.88^{d}

Values are the average of triplicates±standard deviation. For each characteristic, data followed by different letters are significantly ($P< 0.05$) different.

(2010); Ayadi *et al.* (2009); Chen *et al.* (1988); Grigelmo-Miguel *et al.* (1999); Sudha et al (2007), who included different fiber sources to cake recipe and observed a decrease in cake volume. Nevertheless, Gomez *et al.* (2010a) indicated that the cake volume increased when fiber percentage increased to a maximum level and then decreased at higher levels of fiber addition. Cake volume and density are affected by many factors, amongst them batter consistency and the air bubbles entrapped in the batter during mixing seeming to play important roles (see Table 1). It is accepted that the batter consistency must be sufficient enough to retain the air bubbles introduced during mixing, and as well the CO_2 produced by baking powder during baking (Stauffer, 1990; Gomez *et al.,* 2010a). Air bubbles cannot be sufficiently trapped in a batter of very high consistency, while they would easily escape from a batter of very low consistency. Therefore, a small increase in batter consistency could assist in retaining of the gases and increasing of the cake volume. On the contrary, a high increase in batter consistency could hinder expansion and reduce cake volume, resulting in an increase in cake density as observed when high bran quantities and high particle size bran added. The effects of hydrocolloids present in the bran on the pasting and thermal properties of the starch (from wheat flour) as reported by Bárcenas *et al.* (2009) and BeMiller (2011), may be another reason for the effects affecting cake volume and density. It seems that the available water for starch gelatinization (reduced in the presence of rice bran as it absorbs some water) resulted in higher gelatinization temperature of the starch. The interactions of the bran oil and hydrocolloids with starch may also elevate starch gelatinization temperature. When an increase in starch gelatinization temperature occurs, the change of batter to a porous and solid structure takes place later, allowing the cake to undergo increase in its volume for a longer duration resulting in high cake volume (Gomez *et al.,* 2007).

Determination of the weight of the cakes showed that increasing bran level and bran particle size had increasing effect on after bake weight of the cake. The lightest weight was obtained for the control sample and for those treatments containing low bran levels (< 10%) and bran of small particle sizes (< 125 μm). Samples of lightest weight possibly had large air-water contact areas, since their corresponding batter had the lowest density and the highest Bostwick number (see Table 1) with the produced cake bearing the highest volume. The more porous structure of the control sample may lead to greater water loss as compared with other samples. In addition, the components of the bran included in other cake samples, may retain some water resulting in heavier cakes. For the same reason, the baking loss also decreased with an inclusion of more bran of higher particle sizes.

The structure of the cakes depends upon several factors including the volume of the cake and its formulation. Textural analysis of the cakes (Table 3) showed that maximum compressing force and the firmness increased, while cohesiveness and springiness decreased with increasing the level of bran and its particle size. The higher quantity level and larger particle sizes of the bran result in creation of a less cohesive structure of the cake. The results are in agreement with Gomez *et al.* (2010b) who reported a 99.9% significant correlation between cake volume and firmness (r= -0.73). Grigelmo-Miguel *et al.* (1999) also observed an increase in muffin hardness when dietetic fiber was included in the cake recipe. In general, high moisture content would yield a soft product. Nevertheless, cakes containing higher quantity and bigger particle size bran had higher moisture content (Table 3) yielding in higher hardnesses. This may confirm the idea of Chao-Chi Chuang and Yeh (2006) who indicated that water is not the only factor affecting the texture of the final product. Interactions between bran components with those present in the batter including gluten, starch, sugar as well as fat may also affect hardness of the cakes which is in need of further studies. According to Wilderjans *et al.* (2010) starch gel influences crumb firmness while the springiness being related to protein aggregation in the cake crumb.

The crust color of the cakes was affected by increase in the quantity and in the particle size of the rice bran (Table 4). In general, the

Table 3. Textural characteristics of cakes containing different levels and different particle sizes of rice bran.

	Bran level (%)				
Particle Size (μm)	0	5	10	15	20
			Hardness (N)		
53	$2.28±0.01^{d}$	$2.36±0.04^{d}$	$2.42±0.09^{d}$	$2.71±0.07^{c}$	$2.79±0.06^{c}$
125	$2.28±0.01^{d}$	$2.71±0.08^{c}$	$2.80±0.05^{c}$	$2.89±0.14^{c}$	$3.15±0.06^{b}$
210	$2.28±0.01^{d}$	$3.72±0.06^{b}$	$3.73±0.07^{b}$	$3.76±0.11^{b}$	$4.81±0.91^{a}$
			Firmness ($N\ s^{-1}$)		
53	$0.44±0.01^{h}$	$0.44±0.04^{h}$	$0.51±0.09^{f}$	$0.53±0.07^{f}$	$0.55±0.06^{e}$
125	$0.44±0.01^{h}$	$0.49±0.08^{g}$	$0.52±0.05^{f}$	$0.54±0.14^{ef}$	$0.57±0.06^{d}$
210	$0.44±0.01^{h}$	$0.61±0.08^{c}$	$0.70±0.13^{b}$	$0.72±0.11^{b}$	$0.76±0.09^{a}$
			Cohesiveness		
53	$0.81±0.01^{a}$	$0.80±0.03^{a}$	$0.77±0.01^{b}$	$0.77±0.01^{b}$	$0.73±0.01^{c}$
125	$0.81±0.01^{a}$	$0.79±0.00^{ab}$	$0.77±0.02^{abc}$	$0.75±0.02^{c}$	$0.73±0.01^{c}$
210	$0.81±0.01^{a}$	$0.78±0.01^{b}$	$0.77±0.01^{b}$	$0.74±0.01^{c}$	$0.72±0.01^{c}$
			Springiness		
53	$0.99±0.01^{a}$	$0.99±0.02^{a}$	$0.97±0.01^{b}$	$0.97±0.04^{ab}$	$0.96±0.03^{ab}$
125	$0.99±0.01^{a}$	$0.99±0.01^{a}$	$0.97±0.01^{b}$	$0.96±0.02^{ab}$	$0.95±0.01^{b}$
210	$0.99±0.01^{a}$	$0.97±0.01^{b}$	$0.96±0.00^{b}$	$0.91±0.05^{c}$	$0.92±0.03^{c}$

Values are the average of triplicates±standard deviation. For each characteristic, data followed by different letters are significantly (P<0.05) different.

Table 4. Crust color characteristics of cakes containing different levels and different particle sizes of rice bran.

	Bran level (%)				
Particle Size (µm)	0	5	10	15	20
			L-value		
53	51.50±0.58 [a]	50.20±0.96 [ab]	49.20±0.96 [b]	47.20±0.96 [c]	44.20±0.96 [d]
125	51.50±0.58 [a]	45.00±0.82 [d]	44.70±0.96 [d]	37. 50±0.96 [e]	32.20±1.71 [f]
210	51.50±0.58 [a]	44.00±1.41 [d]	40.70±0.96 [d]	37.00±0.96 [e]	32.50±1.29 [f]
			a-value		
53	19.20±0.96 [b]	19.70±0.83 [b]	20.20±1.29 [b]	21.50±1.29 [b]	21.70±1.30 [b]
125	19.20±0.96 [b]	20.70±0.83 [b]	21.70±1.30 [b]	22.00±0.82 [ab]	22.20±0.96 [ab]
210	19.20±0.96 [b]	21.20±0.96 [b]	22.00±0.82 [ab]	22.20±0.96 [ab]	23.00±0.82 [a]
			b-value		
53	52.20±0.96 [a]	50.00±0.82 [b]	48.20±1.26 [c]	46.00±0.82 [de]	43.70±1.26 [f]
125	52.20±0.96 [a]	46.50±0.58 [d]	45.70±0.96 [e]	41.20±0.96 [g]	39.70±0.96 [h]
210	52.20±0.96 [a]	46.00±0.82 [de]	44.50±1.29 [ef]	40.20±0.96 [gh]	39.00±0.82 [h]

Values are the average of triplicates ± standard deviation. For each characteristic, data followed by different letters are significantly (P<0.05) different.

crust became darker (lower L-value), more reddish (higher a-value) and less yellowish (lower b-value) with inclusion of rice bran. Similar changes in the crumb color occurred as a result of addition of bran to the cake recipe (Table 5). The crust color of the cakes is generated during the baking process, due to Maillard reactions between amino acids and sugars and the caramelization process of sugars. Therefore, the differences observed when bran was added could be related to higher protein and sugar content of the bran as compared with the cake flour content. Crumb color highly depends on raw materials used in the cake recipe, but to a lesser extent on Maillard and caramelization reactions since the temperature is not high enough in the cake crumb for these reactions. Natural pigments present in the rice bran are some of the main reasons for changes of the crumb color. Similar results have been reported by Gomez *et al.* (2010b) and Grigelmo-Miguel *et al.* (1999).

Sensory Evaluation Results

The mean scores of hedonic sensory evaluation of the cakes varying in rice bran level are shown in Figure 1. It IS observed that increasing the levels of rice bran, negatively affected taste, crust and crumb color. The scores given to the taste decreased from 5.0 for 0% rice bran to 3.0 for 20% rice bran addition, the scores given to the crust and crumb color were reduced from 4.6 and 4.5 for 0% rice bran to 2.5 and 2.0 for 20% rice bran, respectively. The difference between the values was significant (P< 0.05). In terms of cake texture, the highest score was given to the sample formulated with 10% (Score= 4.7) followed by those formulated with 15% (Score= 4.0) and 20% (Score= 4.4) rice bran addition. These values were not significantly different (P< 0.05). The samples containing 0 and 5% rice bran received the lowest scores [not significantly different from each other (P< 0.05)]. Similar results were obtained for the cake flavor; the score given to the sample containing 10% rice bran was significantly (P< 0.05) higher than those given to the other samples while the lowest scores being given to the samples made with 0 and 5% bran. As regards the overall quality, the cakes prepared with 10% rice bran were the most highly preferred by the panelists (Score= 4.7), whereas the cakes prepared with 20% rice bran the least preferred (Score= 3.0). The cakes containing 0, 5 and 15% rice bran received intermediate scores which did not significantly differ from each other (P< 0.05).

The effect of bran particle size on the sensory attributes of the cakes (Figure 2) revealed that the characteristics of the samples made with smaller bran particle sizes were closer to those of the

Table 5. Crumb color characteristics of cakes containing different levels and different particle sizes of rice bran.

	Bran level (%)				
Particle Size (μm)	0	5	10	15	20
			L-value		
53	72.70±0.95[a]	65.20±1.70[b]	59.50±0.58[c]	58.00±0.82[cd]	52.00±2.16[f]
125	72.70±0.95[a]	58.00±0.82[cd]	56.20±1.70[d]	54.20±1.70[e]	49.00±0.82[g]
210	72.70±0.95[a]	56.20±0.96[d]	54.00±0.82[e]	53.00±0.82[ef]	47.00±1.29[g]
			a-value		
53	3.70±0.96[hi]	4.70±0.96[fg]	5.20±0.96[fg]	6.20±0.96[fe]	7.20±0.96[cd]
125	3.70±0.96[hi]	6.00±0.82[efg]	7.00±0.82[dh]	8.70±0.96[bc]	9.70±0.96[ab]
210	3.70±0.96[hi]	7.70±0.96[cd]	8.00±0.82[cd]	9.50±0.58[ab]	10.70±0.96[a]
			b-value		
53	51.30±1.41[a]	51.20±0.96[a]	49.20±1.70[b]	47.00±1.41[c]	44.00±0.82[d]
125	51.30±1.41[a]	49.20±1.26[b]	48.00±1.41[b]	45.20±0.96[d]	42.20±0.96[e]
210	51.30±1.41[a]	47.20±0.96[c]	45.00±0.82[d]	42.00±0.82[e]	40.00±0.82[f]

Values are the average of triplicates ± standard deviation. For each characteristic, data followed by different letters are significantly (P< 0.05) different.

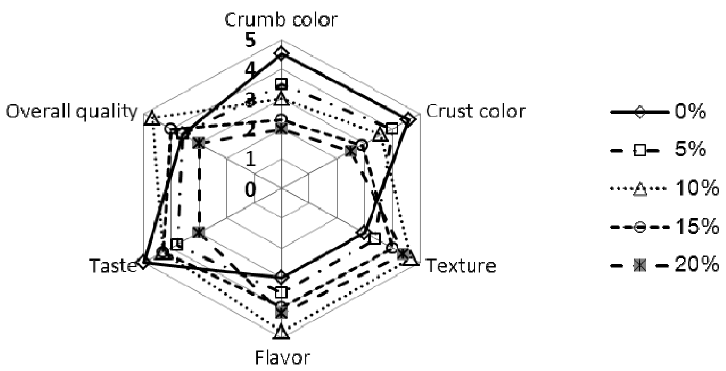

Figure 1. Sensory evaluation of cakes of different levels of rice bran with particle size of 125 μm.

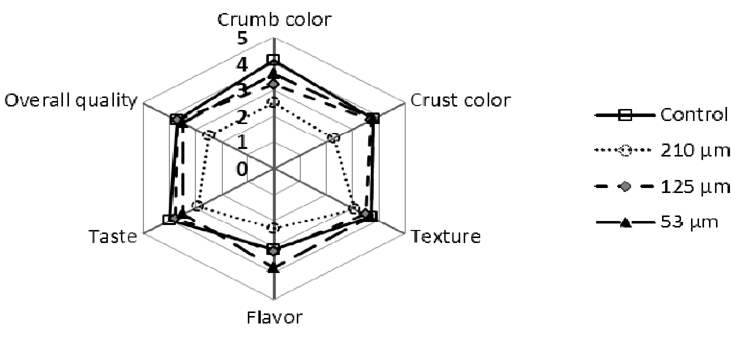

Figure 2. Sensory evaluation of cakes containing 10% rice bran with different particle sizes.

control. The sample prepared with bran particle size of 210 μm received the lowest score in terms of all the sensory attributes as compared with the cakes made with bran of particle sizes of 53 and 125 μm.

CONCLUSIONS

Rice bran containing high level of dietary fiber can function as a valuable source of dietary fiber in cake making. Nevertheless, both particle size and quantity exerted great influence on the batter and cake quality. According to the obtained results, when the substitution quantity of the wheat flour by rice bran was increased to more than 10% and the particle size became larger than 125 μm, the batter density and consistency increased, significantly. This would have great impact on the cake volume, color, textural as well as sensory characteristics. According to the sensory evaluation results, samples containing smaller particle size (< 125 μm) bran received higher scores. Addition of rice bran could improve the texture, flavor and overall quality of the samples as evaluated by the panelists.

REFERENCES

1. Afshari-Jouybari, H. and Farahnaky, A. 2011. Evaluation of Photoshop Software Potential for Food Colorimetry. *J. Food Eng.*, **106:** 170-175.
2. Allais I., Edoura-Gaena, R. B. and Dufour, E. 2006. Characterization of Layer Finger Batters and Biscuits by Fluorescence Spectroscopy-relation with Density, Color and Texture. *J. Food Eng.,* **77:** 896-909.
3. American Association of Cereal Chemists. 2000. *Approved Methods of the American Association of Cereal Chemists*. 10th Edition, American Association of Cereal Chemists. St. Paul, MN.
4. Ayadi, M. A., Abdelmaksoud, W., Ennouri, M. and Attia, H. 2009. Cladodes from *Opuntiaficus indica* as a Source of Dietary Fiber: Effect on Dough Characteristics and Cake Making. *Indust. Crops Prod.,* **30:** 40-47.
5. Bárcenas., M. E., De la O-Keller, J. and Rosell, C. M. 2009. Influence of Different Hydrocolloids on Major Wheat Dough Components Gluten and Starch . *J. Food Eng.,* **94:** 241-247.
6. BeMiller, J. N. 2011. Pasting Paste and Gel Properties of Starch-hydrocolloid Combinations. *Carbohyd. Polym.*, **86:** 386-423.
7. Campbell, G. M. and Mougeot, E. 1999. Creation and Characterization of Aerated Food Products. *Trends Food Sci. Technol.,* **10:** 283-296.
8. Chao-Chi Chuang, G. and Yeh, A. I. 2006. Rheological Characteristics and Texture Attributes of Glutinous Rice Cakes Mochi . *J. Food Eng.,* **74:** 314 – 323.
9. Chen, H., Rubenthaler, G. L., Leung, H. K. and Baranowski, J. D. 1988. Chemical, Physical and Baking Properties of Apple Fiber Compared with Wheat and Oat Bran. *Cereal Chem.,* **65:** 244-247.
10. Cicero, A. F. G. and Derosa, G. 2005. Rice Bran and Its Main Components: Potential Role in the Management of Coronary Risk Factor. *Curr. Top. Nutraceut. Res.,* **3**: 29-46.
11. Gomez, M., Ronda, F., Caballero, P. A., Blanco, C. A. and Rosell, C. M. 2007. Functionality of Different Hydrocolloids on Quality and Shelf Life of Yellow Layer Cakes. *Food Hydrocol.,* **21:** 167-173.
12. Gomez, M., Oliete, B., Rosell, C.M., Pando, V., and Fernandez, E. 2008. Studies on cake quality made of wheat-chickpea flour blends. *LWT Food Sci. Technol.,* **41:** 1701-1709.
13. Gomez, M., Manchon, L., Oliente, B., Ruiz, E. and Caballero, P. A. 2010a. Adequacy of Wholegrain Non-wheat Flours for Layer Cake Elaboration. *LWT Food Sci. Technol.,* **43:** 507-513.
14. Gomez, M., Moraleja, A., Oliete, B., Ruiz, E. and Caballero, P. A. 2010b. Effect of Fiber Size on the Quality of Fiber-enriched Layer Cakes. *LWT Food Sci. Technol.,* **43:** 33-38.
15. Grigelmo-Miguel, N., Carreras-Boladeras, E. and Martin-Belloso, O. 1999. Development of high-fruit-dietary fiber muffins. *Eur. Food Res. Technol.,* **210:** 123-128.
16. Krishnan, P. G., Chang, K. C. and Brown, G. 1987. Effect of Commercial Oat Bran on the Characteristics and Composition of Bread. *Cereal Chem.*, **64:** 55-58.
17. Lebesi, D. M. and Tzia, C. 2011. Effect of the Addition of Different Dietary Fiber and Edible Cereal Bran Sources on the Baking and Sensory Characteristics of Cupcakes. *Food Bioproc. Technol.,* **4:** 710–722.

18. Lu, T. M., Lee, C. C., Mau, J. L. and Lin, S. D. 2010. Quality and Antioxidant Property of Green Tea Sponge Cake. *Food Chem.,* **119:** 1090-1095.
19. Majzoobi, M., Darabzaded, N. and Farahnaky, A. 2012. Effects of Percentage and Particle Size of Wheat Germ on Some Properties of Batter and Cake. *J. Agric. Sci. Technol.,* **14:** 827-836.
20. Rosell, C. M., Rojas, J. A. and Benedito De Barber, C. 2001. Influence of Hydrocolloids on Dough Rheology and Bread Quality. *Food Hydrocol.,* **15:** 75–81.
21. Saunders, R. M. 1990. The Properties of Rice Bran as a Food Stuff. *Cereal Foods Worlds,* **35:** 632-662.
22. Stauffer, C. E. 1990. *Functional Additives for Bakery Foods*. Van Nostrand Reinhold, New York, PP. 189-198.
23. Steffe, J. F. 1996. *Rheological Methods in Food Process Engineering*. Freeman Press, New York, PP. 72-93.
24. Stone, H. and Sidel, J. L. 2004. *Sensory Evaluation Practices*. Elsevier Academic Press, California, PP. 40-90.
25. Sudha, M. L., Baskaran, V. and Leelavathi, K. 2007. Apple Pomace as a Source of Dietary Fiber and Polyphenols and Its Effect on the Rheological Characteristics and Cake Making. *Food Chem.,* **104:** 686-692.
26. Tan, M. C., Chin, N. L. and Yusof, Y. A. 2011. Power Ultrasound Aided Batter Mixing for Sponge Cake Batter. *J. Food Eng.,* **104:** 430-437.
27. Wang, J., Rosell, C. and Benedito de Barber, C. 2002. Effect of the Addition of Different Fibers on Wheat Dough Performance and Bread Quality. *Food Chem.,* **79:** 221-226.
28. Wilderjans, E., Luyts, A., Goesaert, H., Brijs, K. and Delcour, J. A. 2010. A Model Approach to Starch and Protein Functionality in a Pound Cake System. *Food Chem.,* **120:** 44-51.
29. Wilson, T. A., Idreis, H. M., Christopher, M. and Nicolosi, T. R. J. 2002. Whole Fat Rice Bran Reduces the Development of Early Aortic Atherosclerosis in Hypercholestrolemic Hamster Compared with Wheat Bran. *Nutr. Res.*, **22:** 1319-1332.

تاثیر اندازه ذرات و مقدار سبوس برنج بر کیفیت خمیر و کیک اسفنجی

م. مجذوبی، س. شریفی، ب. ایمانی، و ع. فرحناکی

چکیده

سبوس برنج محصول جانبی عمده آسیاب برنج می باشد که حاوی مقدار زیادی فیبر، پروتئین، ویتامین ها، املاح و آنتی اکسیدانها می باشد و لذا می توان از آن برای غنی سازی محصولات غذایی استفاده کرد. هدف اصلی از انجام این تحقیق تعیین تاثیر اندازه ذرات (۳۵، ۱۲۵ و ۲۱۰ میکرومتر) و مقدار (۰، ۵، ۱۰، ۱۵ و ۲۰٪) سبوس برنج بر کیفیت خمیر و کیک اسفنجی می باشد. نتایج حاصل نشان داد که افزایش درصد سبوس و اندازه ذرات باعث افزایش دانسیته خمیر و افزایش قوام آن می گردد. با افزایش غلظت و اندازه ذرات سبوس، دانسیته کیک کاهش ولی حجم آن افزایش یافت. افزایش مقدار و اندازه ذرات سبوس بر وزن کیک بعد از پخت اثر مثبت داشت. خصوصیات بافتی نمونه ها که به روش دستگاهی معین شد نشان داد که با افزایش مقدار و اندازه ذرات سبوس بیشینه نیروی فشاری و شیب افزایش در حالی که پیوستگی و فنریت کاهش بافت. با افزودن سبوس به فرمول کیک تیرگی و قرمزی رنگ پوسته افزایش ولی زردی آن کاهش یافت. بر اساس نظرات اعضاء گروه چشایی، افزایش مقدار سبوس برنج اثرات منفی بر طعم و مزه، رنگ پوسته و مغز کیک داشت. با این وجود مشخص شد که افزودن سبوس برنج به مقدار ۱۰٪ و با اندازه ذرات ۱۲۵ میکرومتر بهترین نتیجه را داشت.