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Cocoa Bean Hulls: Effect on Nutritional Quality, Texture and Sensory Properties of Pound Cake

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ABSTRACT

In this study, wheat flour was substituted with the following ratios of the raw (RCBH) and leached (LCBH) cocoa bean hull (CBH) in pound cakes (PC) (CBH/wheat flour ratios: 20/80 (20%), 30/70 (30%) and 40/60 (40%)), respectively. The proximate composition and the content of bioactive compounds in the cake samples for each weight ratio of RCBH and LCBH and in the hulls were evaluated. Fiber, ash, total antioxidant activity (TAA) and total phenolic compound (TPC) contents increased with the CBH content in the cakes. No significant difference was found in the specific volume among the cake samples. Based on the results of the textural analysis, all cake samples showed higher hardness, lower springiness and cohesiveness than those of the control cake. Regarding to the color of the crumb and crust, the 40% LCBH and RCBH cakes presented the lowest *L**, *a** and *b** values. According to the Principal Component Analysis (PCA), it was observed that the properties with respect to the cell uniformity, adhesiveness, sweetness, oiliness and humidity of the 20LCBH and 20RCBH cakes can be distinguished clearly from the other flour substituted cakes.

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Introduction

Recently, food by-products generated during oilseed processing have been searched for their nutrient and functional contents in order to modify the characteristics of the present foodstuffs. During the extraction of the oil from plant seeds in food industry, a considerable amount of the hulls obtained as by product (Johnson, 1970). A majority of them are discarded; a few amounts can be utilized as raw materials in fertilizer, packaging material, animal feeds and aromatic substances (Arlorio et al., 2005; Bruna et al., 2009). The previous studies have revealed that bioaccessibility and bioavailability of nutshells based on various effects on human health such as antioxidative, anti-inflammatory, prebiotic, chemically protective properties and hypocholesterolemia effect which result from phenolic compounds found in nutshells (Chang et al., 2016). In another study, the antioxidant activities of the oilseed hulls were associated with the presence of phytochemicals which provide protective effects against free radicals. Moreover, plant based chemicals includes anti-carcinogenic, anti-mutagenic, anti-proliferative effects (Alasalvar and Shahidi, 2008). Cocoa bean hulls (CBH), regarded as the waste products in cocoa and chocolate industry are composed of approximately 12-15% of cocoa bean (Kopp et al., 2011). CBH is the primary by-products of cocoa, which exhibit high content of polyphenols. They contain some phenolic compounds in significant amounts and could be used as a food ingredient for the improvement of functional food qualities owing to their contribution the total antioxidant activity (TAA) (Martínez et al., 2012). There is an increasing trend to evaluate CBH in functional foods because of antioxidant and antiradical properties of the polyphenolic constituents (Bruna et al., 2009). Furthermore, it was reported that cocoa contains the most alkaloid theobromine and caffeine (Timbie et al., 1978; Pritchard, 1991)

Studies in the past evaluated the effects of oilseed hulls and nutshells used in various baking products in order to improve the chemical, textural and sensory properties (Hao and Beta, 2012; Pourfarzad et al., 2013; Dall'Asta et al., 2013). Peanut skin added to cookies increased their total phenolic compound (TPC) and gave rise to the improvement of their sensorial properties (Camargo et al., 2014). Flaxseed hulls have been used in bread as well. The TPC, free radical scavenging activity, reducing power properties increased due to the fortification by flaxseed hull. Bread samples were also evaluated for physical and textural properties in order to determine the optimal formulations (Sęczyk et al., 2017).

Investigations of CBH in food formulations are limited. Martinez-Cervera et al. (2011) used soluble cocoa fiber produced from CBH the production of chocolate muffins with the different amounts as a fat replacer. The results issued that soluble cocoa fiber could be used as a fat substitute in chocolate muffin making.

In this study it was aimed to evaluate the use of CBH as a by-product of cocoa bean processing in order to produce flour substituted cakes (FSC) enriched with fiber and bioactive components. For this purpose the effects of substitution with the raw cocoa bean hull (RCBH) and leached cocoa bean hull (LCBH) on the final product were also formulated. The quality and sensory properties of the novel foods fortified with the RCBH and LCBH were compared.

Materials and Methods

RCBH (Raw Cocoa Bean Hull)

The cocoa bean hull to be used in the research were obtained from Ülker Çikolata Sanayi A.Ş. They were ground in a hammer mill grinder (Brook Crompton Controls, Wakefield, England) and sieved by 60-mesh to obtain a particle size smaller than 283 µm. In other words, the ground and sieved cocoa bean hulls were used as the untreated dietary fiber. They are also called as RCBH.

LCBH (Leached Cocoa Bean Hull)

The ground and sieved RCBH called as LCBH were treated with the hot water as described by Garcia-Serna et al. (2014). For this purpose, 3.3 g of RCBH were treated with 100 ml of boiling water for 10 min (Garcia-Serna et al., 2014). The solid residue from the extraction process was recovered by the filtration using a filter paper. Following a drying process at room temperature for 24 hours, the residue was exposed to a further drying in an oven at 60±2°C for 8-h and also was sieved to a particle size smaller than 283 µm, respectively.

Cake Formulations

The cake formulations were prepared using the following ingredients: 26.14% wheat flour, 26.14% sugar, 12.03% sunflower oil, 21.18% egg, 13.07% whole milk, 0.39% salt, 1.05% baking powder for control cake (Martínez-Cervera et al., 2011; Kocer et al., 2007). The ground and sieved powder of the RCBH and LCBH was added into the cakes at three different weight ratios (20%, 30% and 40%; w/w) by replacing equal weight ratios of wheat flour of the cake mixture. Relying on their weight ratios in the substitution, the cakes fortified by the RCBH were referred as 20RCBH, 30RCBH, 40RCBH. The same nomenclature was also used for the samples enriched with the LCBH. The batter was weighed (600 g) into the Teflon cake mold (31×12×7 cm) and baked in a preheated oven (Arçelik SUF4000 MEB, İstanbul, Turkey) at 170°C for 55 min. The cakes were milled to a powdered form using a coffee grinder and their methanolic extracts were stored at -18°C in airtight vials.

Proximate Composition of the CBH and Cake Samples

The moisture, ash, fat, protein, and crude fiber contents of the RCBH and LCBH were determined by AOAC methods: 925.10, 942.05, 963.15, 968.06, and 962.09, respectively (AOAC, 2007). The moisture of the cake samples was measured based on the Method 44-40 (AACC, 2000). The ash, fat, protein and crude fiber of the cakes and CBH were also determined and expressed on the dry basis.

Physicochemical Composition of CBH

The water retention capacity (WRC) of the RCBH and LCBH were determined by mixing 2,5 g of sample with 30 ml distilled water. The mixtures were vortexed for 1 min and then centrifuged at 5000 rpm for 20 min, and the volume of supernatant was calculated (Yang et al., 2014). The water solubility index (WSI) of the RCBH and LCBH were calculated by dried supernatant at 40°C for 12 hours based on moisture loss in supernatant (Yang et al., 2014).

Bioactive Compound Composition of the CBH and Cake Samples

Two grams of the CBH powder was weighed, and 40 ml of 80% methanol was added. The solution was shaken at 142 rpm for 2 hours via DAIHAN Wise Shake SHO Digital Orbital Shaker, respectively. The mixture was centrifuged (Mistral 1000) at 4500 rpm for 15 min. The supernatant was transferred to a 50 ml volumetric flask, and completed with 80% methanol solution. The cake samples were grinded by the coffee mill (Sinbo SCM-2910) and defatted by the treatment with the chloroform:petroleum ether (v/v, 50:50) solution. The defatted cake samples were extracted by the same methods used for the CBH powder extraction (Skerget et al., 2005; Balestra et al., 2011). Afterwards, the CBH and cake extracts were analysed for the TPC, total flavonoid content (TFC) and TAA.

The TPC of all samples was determined using the Folin Ciocalteu method described by Heimler et al. (2005). The absorbance was measured at 765 nm using a spectrophotometer. The results were expressed as g of gallic acid equivalents (GAE) /100 g on dry matter (DM).

The TAA was determined according to Saija et al. (1998) and Rapisarda et al. (1999). The absorbance was measured at 517 nm. The results were expressed as µmol Trolox/g on DM.

The caffeine and theobromine contents of the RCBH and LCBH powder were measured according to the AOAC method 980.14 (AOAC, 2007). The HPLC-DAD was performed at 280 nm. The results were expressed as g/100 g on DM.

Physical Composition of Cake Samples

The baking loss was calculated as the ratio of the weight of batter before baking to the weight of the cake after baking (Martínez-Cervera et al., 2011). The specific volume was measured using rapeseed displacement Method 10.05 (AACC, 2000) and it was calculated as the ratio of the cake's volume to its weight.

Texture and Colour Determination

The texture profile analyses (TPA) of the cakes were measured using a TA.XT.plus Texture Analyser (Stable Microsystems, Godalming, UK) equipped with a load cell of 5 kg.

A double compression test was carried out to a height of 1.25 cm (40% compression) using a cylindrical aluminium probe (36 mm diameter) at a speed of 1 mm/s with a waiting time of 5 s between the two cycles. The cake crumb hardness (CCH) was determined by the AACC method 74.09 (AACC, 2000). The springiness, cohesiveness and chewiness values were calculated from the TPA graph. Cake loaves were cut into 25 mm thick slices from the centre for a standard texture profile analysis. Duplicate analysis was also made.

The colour of the cake's crust (CR) and crumb (CB) was measured using a Minolta colorimeter (CR-400, Konica Minolta Sensing, Inc., Osaka, Japan). It was expressed with $L*$ (black=0, white=100), $a*$ (redness>0, greenness<0), $b*$ (yellowness>0 blueness<0) values (Chen et al., 2010). The colour measurements of the CR were made on the five different pre-selected locations for each loaf while the colour of the CB was measured on five central slices of each sample for the cakes (Martínez-Cervera et al., 2011).

Sensory Analysis of FSC

In the preliminary studies, 10%, 20%, 30%, 40%, 50% and 60% of the CBH as FSC samples were evaluated by the ranking test in order to select the most appropriate ratio of the hulls to be used in the cake formulations. The cakes were evaluated according to the colour, texture (hand and mouth), taste and overall acceptance criteria. For the statistical evaluation of the results obtained in FSC, the acceptable score was determined between 25 and 48 in the 5% confidence interval corresponding to 6 treatments and 11 replicates (Altuğ and Elmacı, 2015).

The descriptive sensory analysis was applied to the FSC. Six trained assessors were used in the sensory analysis. During the training sessions, the appearance, texture and flavour characteristics of the cakes were evaluated using a 7 cm unstructured line scale (0- none and 10 extreme). The sensory analysis was performed twice at room temperature individually. Each cake formulation was prepared twice and evaluated at two separate sessions within the day. The assessors received only a single cake formulation at a session. The definitions made for the evaluations of the sensory properties are shown on Table 1.

Statistical Analysis

The RCBH and LCBH analyses have been conducted in triplicate, whereas the cake formulations were prepared in duplicate and the analyses were performed in duplicate. IBM SPSS 20 software was used to evaluate the results. The results for the RCBH and LCBH were determined by the independent t-test. The physical, chemical and sensory quality of cake formulations replaced by RCBH and LCBH at different percentages (0, 20, 30 and 40%) were evaluated with the analysis of variance (ANOVA), respectively. Significant differences among groups at the level of 0.05 were determined by Duncan's multiple range tests. The results were evaluated at a 95% confidence interval. Moreover, the differences in sensory characteristics among the cakes were tested by the PCA using XLSTAT version 2013.1.

Table 1. Descriptive terms and definitions used in sensory analysis of cakes by trained panelists

Terms	Definitions
Appearance	
Crumb brownness	Typical cocoa colour in cake crumb
Cell uniformity	Amount and size of gas cells, homogeneity of air bubbles
Texture (hand)	
Hardness (hand)	Speed of crumb shape recovery when pressure applied by a finger and then is removed
Adhesiveness	Easily roll a piece of cake crumb
Texture (mouth)	
Hardness (mouth)	Resistance to chewing and difficulty in swallowing
Oiliness	Oiliness in the mouth
Moistness	Cake moisture in the mouth
Fibrousness	Residual in the mouth
Flavour	
Cocoa taste	Typical cocoa taste intensity
Bitterness	Bitterness from cocoa
Odor	Fruity woody odor
Sweetness	Sweetness intensity

Results and discussion

Chemical Properties of the CBH

Table 2 summarized the proximate composition of the RCBH and LCBH. The ash and protein content of the LCBH was significantly lower than those of the RCBH ($P<0.05$). One might conclude that these chemical properties decreased with the leaching process (LP). In a study related to the CBH growing in the Cone and Taura regions, the moisture (7.71-7.80 g/100 g), ash (7.35-6.76 g/100 g DM), protein (15.85-15.79 g/100 g DM), fat (2.02-2.05 g/100 g DM) contents of CBH showed similar results, respectively (Martinez et al., 2012). The crude fiber contents of CBH were determined as %19.70 by Altuğ (1987) which were similar to Table 2 crude fiber value of the RCBH. In another study, fat, protein and fiber content (FPFC) of CBH were found between 3.1-5.2%; 14.5-21.6% and 17.4-20.9%, respectively (Adamafio, 2013).

The FPFC of the RCBH powder in Table 2 were found in the range of literature data. Arlorio et al. (2005) also found that CBH contain 68.1 g/kg fat, 181.2 g/kg protein; 81 g/kg ash and 60.6 g/kg fiber content (Martinez et al., 2012). WRC of a substance refers to the amount of the insoluble matter in water and the WSI refers to the amount of water-soluble material (Robertson et al., 2000; Yang et al., 2014). Accordingly, the WRC and WSI of RCBH decreased significantly with the LP (P<0.05). When the WSI of soybean hulls was investigated, results showed similarly with CBH (Yang et al., 2014). The WSI of the RCBH are five times higher than that of the LCBH, indicating that the LP removed the water-soluble components. In literature, the WSI of soybean hulls decreased approximately by 500% by means of the leaching process. The WSI of leached soybean hull powder is less than the WSI of the raw soybean hull powder. By the LP, 57% of caffeine and 69% of theobromine were removed from the CBH. When the results are statistically evaluated, it was seen that the LP applied to the CBH caused a significant reduction in the amount of caffeine and theobromine (P<0.05) (Table 2). Altuğ (1987) determined the caffeine and theobromine values of CBH as 0.80% and 0.06%.

Table 2. Proximate analysis, physico-chemical properties and bioactive compounds of RCBH and LCBH

	RCBH	LCBH
Moisture (g/100g)	6.36±0.12^a	9.57±1.62^b
Ash (g/100g dm*)	11.42±1.46^a	5.22±0.11^b
Protein (g/100g dm)	16.05±0.09^a	14.82±0.27^b
Fat (g/100g dm)	4.37±0.38^a	4.70±0.48^a
Crude fiber (g/100g dm)	17.66±0.27^a	18.48±0.13^a
Water retention capacity (g water/g dm)	3.43±0.16^a	2.31±0.12^b
Water retention index (%)	20.26±0.93^a	3.80±0.37^b
Total phenolic compounds (mg GAE**/100g dm)	370.97±0.03^a	39.25±2.26^b
Total antioxidant activity (µmol Troloks/g dm)	17.27±0.46^a	2.38±0.17^b
Caffeine (g/100 g dm)	0.07±0.00^a	0.03±0.00^b
Teobromine (g/100 g dm)	0.72±0.72^a	0.22±0.22^b

Means ± standard deviation followed by different letters within a column for each cultivar are significantly different at P<0.05, *dm=dry matter, **GAE=gallic acid equivalent

TPC and TAC Values of CBH

The methanol extracts of RCBH and LCBH were examined for their TPC and TAA (Table 2). The results are evident for a significant decrease in the TPC and TAA values by LP (P<0.05). In the literature, the TPC of CBH grown in Madagascar, Ghana, Venezuela, Ecuador, Trinidad regions was found between 256-406 mg GAE/100 g (Bruna et al., 2009). In the study of Bruna et al. (2009), it was demonstrated that TAA showed a high correlation with polyphenol contents of CBH and it was reported that CBH from different geographic origins showed significant difference. In this study, TPC content was also found between the ranges as reported in literature. The related studies pointed out that TPC of cocoa hulls was determined as 18.2 g Catechin/kg (Arlorio et al., 2005). In an another study, the TPC (5.78 g GAE/100 g) and TAA were measured by FRAP (72.32 µmol Trolox/g) and TEAC (7.73 µmol Trolox/g) methods of the fiber-rich CBH obtained from the cocoa kernel (Lecumberri et al., 2007). In another study, TPC and TAA of CBH whose regions were Cone and Taura was evaluated. TPC values of the CBH were found 154.43 and 144.83 mg GAE / 100 g with the methanol: acetone which were higher than the value of the extracts in ethanol (80.17 and 82.37 mg GAE/100 g), respectively. In the DPPH assay, TAA of hulls were determined in methanol: acetone extracts as 3.81 and 4.05 µM of Trolox/g which were also higher than the values of the ethanolic extracts (1.57 and 1.71 µM of Trolox/g) for Cone and Taura respectively. Hence, one might claim the TPC and antioxidant levels of hulls were affected by the regions of cocoa beans and type of solvents used for the extraction. Thus, the difference between the ranges reported in the previous studies might depend on this fact (Martinez et al., 2012). The TAA values were determined by QUENCHER method and also found to be 14.3 mmol Trolox/kg in the peanut, 6.5 mmol Trolox/kg in the pine nuts, 8.1 mmol Trolox/kg in the cashew nuts, 6.0 mmol Trolox/kg in the coconut flour, 12.0 mmol Trolox/kg in the sesame seeds/kg and 6.6 mmol Trolox/kg in the pumpkin seeds (Açar et al., 2009). The RCBH given in Table 2 exhibited higher TAA than those of oilseeds and nuts.

Chemical Properties of FSC

Regarding the chemical composition of the pound cakes (PC), there is a significant difference between the control and 30 RCBH, 40RCBH, 40LCBH are reported in Table 3 (P<0.05). Furthermore, ash and crude fiber content of the cake samples given in Table 3 significantly increased with the addition of LCBH and RCBH (P<0.05). In a study which inspected the muffin samples used as substitutes of Idared apple peel powder as 0%-32%, the moisture values 31.39%-30.93% and ash values 1.39%-1.54% were determined (Rupasinghe et al., 2008). Higher moisture and lower ash contents of muffins were obtained compared with this study. Table 3 shows the data for protein contents no significant difference was found among the RCBH and LCBH substituted cakes except from 40LCBH (P>0.05).

TPC and TAC Values of PC

The TPC content of the PC increased significantly by the addition of the CBH (P<0.05). The TPC content of the cakes substituted with the RCBH revealed a significant difference as compared to that of the cakes substituted with the LCBH (P<0.05). The TPC content of CBH decreased significantly by LP (P<0.05). Table 3 shows the data for the TAA of the different PC. One might state that the use of RCBH as a flour replacement significantly affected the TAC values. Furthermore, cake samples substituted with flour which were produced by the LCBH indicated significantly less TAC values (P<0.05). Similar results were found in other studies in relation to the evaluation of the by-products rich in antioxidants (Dall'Asta et al., 2013; Hayta et al., 2014). Dall'Asta et al. (2013) added the chestnut flour in bread making and determined the antioxidant capacity of the bread samples 0.73, 1.00, 1.04 µmol Troloks/g DM for the control, 20% and 50% flour substituted breads, respectively. Hayta et al. (2012) studied on the TPC of grape pomace added breads by replacing the flour with the grape pomace powder in the ratios of 2%, 5%, 10%. They reported the TPC of control bread as 35.39 mg GAE/100g DM and 53.42, 67.51, 89.43mg GAE/100g DM for the 2%-5%-10% bread samples. The phenolic and antioxidant contents of the cakes containing CBH produced in the study were found to be higher than the bakery products produced with some other food by-products such as chestnut and grape pomace substituted breads. The TPC contents of the bread fortified with CBH were higher than those of Hayta et al. (2012). However, that was due to the addition levels of CBH were higher than of Hayta et al. (2012). Sęczyk et al. (2017) investigated the fortification of bread by the addition of the flaxseed hulls. In this study, it was stated the TPC, the free radical scavenging activity and the reducing power in the breads enriched with the flaxseed hull significantly higher than the control bread. From the point of view of the physical properties, one might conclude that the hardness of the bread was increasing with the addition of hulls while the bread volume was decreasing significantly (P<0.05).

Physical Characteristics of PC

Table 3 shows the specific volume decreased by the increment in the ratio of the CBH added into the cakes (P>0.05). Based on the interaction of gluten and fiber, expression of gas cells has been limited by expansion, resulting in the decline of the cake volume (Dhingra and Jood, 2004). Thus, the specific volume of PC was reduced as the fiber content of the cake formulation rose. The baking loss fell down by the addition of the CBH in the cake samples. These issues were determined as statistically significant among the control sample, 20RCBH and 20LCBH (P<0.05). These results were in agreement with those obtained by Belghith-Fendri et al. (2016) who reported that the specific volume and baking loss of the cakes decreased in the wheat flour fortified with pea pod and broad bean pod powder at the levels of 5-10-15-20-25-30% when compared to those of the control cakes. The color parameters of CR and CB are reported in Table 4.

Table 3. Chemical compositions and physical characteristics of cakes

CS	CHR	M	A	P	CF	TPC	TAA	SV	BL
Control	0	29.26±0.35^{b}	2.29±0.16^{a}	8.14±0.17^{b}	0.55±0.39^{a}	17.34±0.82^{a}	0.70±0.02^{a}	2.16±0.20^{a}	7.29±0.34^{b}
RCBH	20	26.78±0.84^{a,b}	2.64±0.12^{a,b}	7.45±0.07^{a}	1.82±0.05^{b}	72.73±4.15^{b,c}	3.04±0.07^{c}	2.11±0.10^{a}	5.95±0.27^{a}
	30	26.31±0.27^{a}	2.52±0.21^{a,b}	7.55±0.05^{a}	2.00±0.75^{b}	91.94±0.02^{d}	4.22±0.41^{d}	2.09±0.06^{a}	6.64±0.66^{a,b}
	40	25.98±0.43^{a}	2.80±0.21^{b}	7.56±0.27^{a}	3.85±0.10^{d}	107.79±1.22^{e}	4.74±0.71^{d}	2.08±0.04^{a}	6.82±0.37^{a,b}
LCBH	20	26.80±1.43^{a,b}	2.48±0.17^{a,b}	7.62±0.18^{a}	2.22±0.04^{b,c}	67.98±7.24^{b}	0.70±0.02^{a}	2.01±0.04^{a}	6.06±0.18^{a}
	30	27.74±0.19^{b}	2.75±0.26^{b}	7.71±0.41^{a}	3.12±0.39^{c,d}	75.77±8.48^{c}	1.48±0.98^{b}	1.99±0.08^{a}	6.85±0.29^{a,b}
	40	26.05±0.87^{a}	3.38±0.43^{c}	8.25±0.36^{b}	4.90±0.44^{e}	79.08±3.89^{c}	1.50±0.18^{b}	2.03±0.03^{a}	6.93±0.51^{a,b}

CS: Cake samples, CHR: Cocoa hull ratios (%), M: Moisture (g/100g), A: Ash (g/100g dm*), P: Protein (g/100g dm), CF: Crude fiber (g/100g dm), TPC: Total phenolic compounds (mg GAE**/100 g dm), TAA: Total antioxidant activity (µmol Troloks/g dm), SV: Specific volume (cm^3/g), BL: Baking loss (%), Means ± standard deviation followed by different letters within a column for each cultivar are significantly different at P<0.05, *dm=dry matter, **GAE=gallic acid equivalent

Table 4. Colour and texture properties of cakes

CS	CH	Crust			Crumb		
		*L**	*a**	*b**	*L**	*a**	*b**
Control	0	47.10±1.40^{c}	13.58±1.25^{e}	15.76±3.57^{c}	70.76±1.20^{e}	-0.85±0.35^{a}	22.40±0.54^{e}
RCBH	20	36.13±1.91^{b}	9.10±0.44^{d}	6.12±1.19^{b}	33.39±1.77^{d}	8.37±0.24^{g}	6.34±0.52^{d}
	30	33.41±2.34^{a}	7.36±0.31^{c}	2.83±0.77^{a}	30.86±1.48^{c}	7.77±0.50^{f}	3.60±0.76^{c}
	40	33.43±1.79^{a}	6.38±0.44^{b}	1.67±0.58^{a}	29.50±1.59^{b,c}	7.03±0.51^{e}	1.83±0.72^{b}
LCBH	20	37.75±3.63^{b}	7.81±0.62^{c}	7.68±1.99^{b}	32.95±3.57^{d}	6.19±0.38^{c}	3.99±1.17^{c}
	30	33.74±2.38^{a}	5.50±0.15^{a}	2.75±1.09^{a}	28.61±2.61^{a,b}	5.50±0.23^{b}	1.01±0.63^{a}
	40	33.18±1.76^{a}	5.21±0.30^{a}	2.25±1.36^{a}	27.17±2.28^{a}	5.01±0.21^{a}	0.51±0.40^{a}

CS	CH	Texture			
		Hardness (N)	Springiness	Cohesiveness	Chewiness (N)
Control	0	11.45±0.86^{a}	0.94±0.02^{b}	0.77±0.00^{e}	8.23±0.55^{a}
RCBH	20	12.74±2.57^{a,b}	0.91±0.06^{b}	0.62±0.03^{d}	7.25±1.93^{a}
	30	15.66±3.34^{b,c}	0.89±0.04^{b}	0.56±0.03^{b,c}	7.83±2.03^{a,b}
	40	17.46±4.09^{c,d}	0.83±0.04^{a}	0.50±0.02^{a}	7.28±2.11^{a}
LCBH	20	14.69±1.74^{a,b,c}	0.93±0.02^{b}	0.63±0.00^{d}	8.56±1.03^{a,b}
	30	18.65±1.74^{c,d}	0.88±0.03^{b}	0.58±0.02^{c}	9.64±1.35^{a,b}
	40	21.20±2.40^{d}	0.89±0.03^{b}	0.53±0.03^{a,b}	9.90±1.18^{a,b}

CS: Cake samples, CH: Cocoa hull ratios (%), Means ± standard deviation followed by different letters within a column for each cultivar are significantly different at P<0.05

The *L*, *a* and *b* colour values of CB enriched with LCBH were less than the ones of the samples enriched with the RCBH. The values for redness and yellowness of CB decreased by the increase in the ratios of CBH added into the samples and the values of LCBH were significantly less than those of the RCBH. As a result, the original colour parameter (a value) of CBH had a darkening effect on the CB. The findings of the previous studies support the addition of food by-products on bakery formulations. It was reported that the colour of the products such as coffee silverskin added to biscuits also influenced their colour (Garcia-Serna et al., 2014). The textural properties of seven cake samples are reported in Table 4.

The CCH of the control cake was significantly less than the ones of the 30% and 40% RCBH and LCBH cakes (P<0.05). Only the cohesiveness fell significantly with the increasing levels of the CBH added to the samples. In regard to the springiness, only the value of the 40RCBH was significantly lower than the one of the control sample (P<0.05). Table 4 illustrated no statistically significant difference among the FSC and control cake with respect of the cake's chewiness (P>0.05). Dall'Asta et al. (2013) reported the hardness of the bread sample substituted with the 50% chestnut flour. They revealed that the cohesiveness and chewiness of those samples were significantly higher than the values of the control bread (P<0.05).

Sensorial Properties of PC

According to the ranking test, the cakes substituted with the flour were not significantly different (P<0.05) in terms of taste and overall acceptance. The maximum preferable weight ratio (Overall acceptance) for the CBH in the cakes was determined 60%. On the other hand, the cakes substituted with the 20%, 30% and 40% flour ratios showed statistically significant differences in terms of texture and color (P>0.05). The ranking test results indicated that the formulation would be prepared by the addition of the CBH up to the ratio of 40% which would not adversely affect the sensory properties of the cakes.

Figure 1 shows the twelve descriptive properties of the PC. As the amount of cocoa hulls increased in the cake samples, the properties such as crumb brownness, hardness (hand), cocoa taste, bitter taste, and odour were perceived with increasing amounts of cocoa bean in RCBH and LCBH cakes. The differences in the values of cell uniformity, adhesiveness, hardness (mouth), oiliness, moistness, fibrousness, sweetness were found to be insignificant by the panellists (P>0.05). In terms of the cell uniformity, hardness (hand), adhesiveness, cocoa taste and bitter taste, the cake samples produced with the LCBH had lower scores than the samples to which CBH was added at the same concentration. In the literature, springiness, cohesiveness, difficulty in chewing and swallowing, bitter taste, chocolate taste, sweetness of soluble cocoa fiber substituted muffins were perceived distinctively (Martinez-Cervera et al., 2011). As it is shown in Figure 2, the clustering analysis and principal component analysis (PCA) were applied using twelve different sensory definitions developed to demonstrate the relationship between FSC. The cluster analysis indicated that there were three basic groups of flour-replacing cakes (Figure 2A). The first group was composed of 20RCBH and 20LCBH, the second group consists of 30RCBH, 30LCBH and 40LCBH and the third group include the 40RCBH. In order to determine the effects of the components in the grouping, 5 basic components, namely F1, F2, F3, F4 and F5, which constitute 64.54%, 23.61%, 6.79%, 3.62%, 1.53% of the total variation in the PCA applied to the samples were obtained respectively. From the biplot diagram drawn by considering the basic components of F1 and F2, cell uniformity, adhesiveness, sweetness, oiliness and humidity values of 20LCBH and 20RCBH were distinguishable from those of the other samples. The 30LCBH and 40LCBH samples differ from the 30RCBH and 40RCBH samples in terms of hardness (in the mouth), odour, fibrousness, and crumb brownness (Figure 2B). The 40RCBH differs distinctively from the 30RCBH, 30LCBH and 40LCBH samples in terms of hardness (hand and mouth), cocoa taste, bitter taste, crumb brownness, fibrousness, odor properties being effective (Figure 2B).

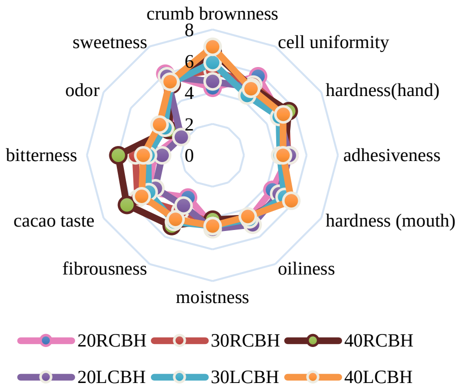
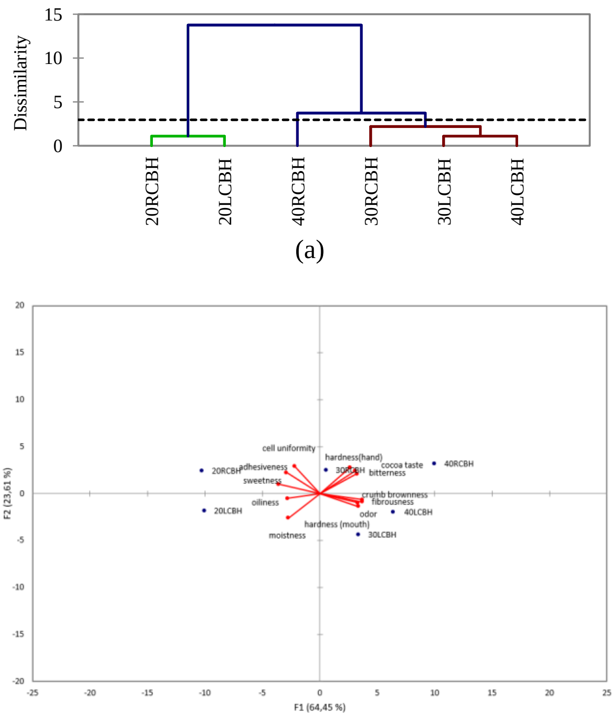


Figure 1. Descriptive sensory analysis of flour substituted cakes



(b)

Figure 2. Principal component analysis of descriptive sensory analysis. (a) Dendogram of cluster analysis. (b) Biplot diagram

Conclusions

According to the findings of this research, ash, protein, WRC, WSI, TPC, TFC, TAA, caffeine and theobromine contents of CBH decreased as a result of LP. Therefore, TPC and TAA of the cakes produced from LCBH were found to be less. The cakes produced using flour which included bioactive compounds and crude fiber differed significantly from the control cake. The effects of CBH on the physical properties of the cakes were evaluated; the baking loss of them decreased with respect to the value of the control cake while the specific volume showed no significant difference. According to the results of the textural analysis of the cakes containing CBH, the greater amount of CBH present in the samples, the higher hardness of the cake. The results of the descriptive sensorial properties are in accordance with those of the textural properties of the cakes. Consequently, it was determined that the use of the RCBH could be beneficial in terms of the enhancement of the chemical, physical and sensorial properties. Moreover, the 40RCBH could be recommended for the production of functional cakes as the flour substitutes. As a result of this study, the CBH can be evaluated in the development of functional novel foods.

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