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Physicochemical evaluation of carob pods (*Ceratonia siliqua* L.) powder and the effect of its addition on cupcake quality

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Abstract

Fiber enrichment of carob pods powder (CPP), sugar and fat replacement are third effective ways in the creation of a healthy diet. This work was conducted to evaluate the effect of partial fat/or sugar replaced cupcakes made from wheat flour WF (72% ext.) by different levels (20, 40, 60, 80 and 100%) of carob pods powder CPP. Comparing between WF and CPP, data revealed that CPP had higher content of fat (2.10%), ash (3.33%), crude fiber (18.58%), phenolic compounds (1800 mg GAE / 100 g), antioxidant activity (17.2%), K (848 mg/100 g), Ca (212.540 mg / 100g), and Fe (38.15 mg/100g). Evaluating cupcakes chemically, physically, rheologically and organoleptically. Chemical composition of fat and/or sugar replaced cupcakes were high in ash content, crude fiber, phenolic compounds and antioxidant activity, while it was low in nitrogen free extract (NFE), protein and caloric values. Moreover, Fe, Zn, Ca and Mg contents were significantly improved. Results indicated that using CPP as a fat or sugar replacers, gradually increased the sensory characteristics with increasing the levels for up to 60% of replacing level, and still acceptable until the highest level of replacing. Findings showed that additives 40 or 60% of CPP as a fat or sugar replacer respectively, increased the water absorption, dough development time, degree of weakening and extensibility, Meanwhile, decreased stability time, resistance to extension, energy and proportional number. Noteworthy, lead to reduce the caloric value and staling case. It could be concluded that the supplementation WF with40 or 60% of CPP used as a fat and /or sugar replacer for cupcakes making to enhance the nutritional values, sensory and rheological properties without adverse effects on the physical and sensory attributes.

Keywords: antioxidant activity, carob pods, phenolic compound, rheological properties, sensory evaluation, wheat flour.

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1. Introduction

Cakes are considered one of the most important bakery products for Egyptian people. It has a great acceptable for every member in the family, especially kids and adolescent. It provides them with large amount of carbohydrates, proteins and fat which they need it to build their bodies (Hefny, 2017). Wheat is the second most produced food among the cereal crops after rice (Dervas *et al.*, 1999). Wheat main dietary contribution is carbohydrates besides these they also provide protein and a smaller amount of lipid, fiber and vitamin (El-Naggar, 2014). The rise in cardiovascular disease and obesity and in other diet-related illnesses (Anderson, *et al.*, 2009) has led to consumers taking a greater interest in the ingredients of food products and valuing those with a reduced fat and sugar content more positively (James and Mark, 2010). Moreover, because of the lifestyle and habits of the population, fiber consumption continues to be below the recommended rates (Dervas *et al.*, 1999). Phytochemicals in diet could provide protection against several threads like free radical formation, degenerative disorders and lifestyle related diseases (Hussein *et al.*, 2012). Carob (*Ceratonia siliqua*) belongs to the subfamily *Caesalpinioideae* of the *leguminosae* family. The fruit of carob tree is composed of pod (90%) and seeds (10%) (Barroso *et al.*, 2015). Carob pods are characterized by a high sugar content (more than 50%) mainly composed of sucrose. High content of carbohydrates (45% sucrose at more than 30 %), appreciable amounts of protein (3%) and low levels of fat (0.06 %) were detected, and rich in insoluble dietary fiber as well as containing attractive quantities of antioxidant compounds (El-Mostapha *et al.*, 2010; Khlifa *et al.*, 2013). Jambi (2015a) studied the phenolic fraction of carob pods by HPLC coupled with electrospray ionization tandem mass spectrometry (HPLC-ESI MS/MS) and gas-chromatography mass spectrometry (GC-MS). A total of 24 polyphenol compounds were identified with a yield of 3.94 gm/kg (dry weight). The profile was dominated by Gallic acid in various forms: free Gallic acid (42% of polyphenols by weight), gallotanins (29%) and methyl gallate (1%), while simple phenols, mainly cinnamic acid, made up about 2 % of the polyphenols and the major components were identified as the glycosides myricetin and quercetin -3-0-α-1 rhamnoside (ca. 9% and 10% resp.). Additionally, carob contains about 18% cellulose and hemicellulose (Bouzouita *et al.*, 2007; Jambi 2015b; Sebai *et al.*, 2013). In the field of sweet bakery products, studies have been carried out to replace part of the fat and/or suger with B-glucan concentrates prepared from barley and oats. The carob pulp is roasted and milled to reduce carob pods powder. Its flavor and appearance are similar to cocoa (Martinez-Cervera *et al.*, 2011). In other studies, part of the flour has been replaced with different types of legumes seed flour or its legume protein isolate (Hefny, 2017). The functional and nutritional properties of CPP has appeared well suited to its usage as partial sugar or fat replacer in baked goods like cup-cakes. Due to *Ceratonia* *siliqua* chemical composition, it's used in the food industry and in medicine (Yousef *et al*., 2013). It`s used as a cocoa substitute in baking cereal bars, chocolate confectionary ice-cream and light products (Salem and Fahad, 2012). Carob has revealed interesting lipid lowering (Zunft *et al.*, 2001), a cholesterol lowering effect and an increase excretion of cholesterol and bile acids (Barroso *et al.,* 2015), nephroprotective (Ahmed, 2010), anti-cardiovascular, anti-proliferative and anti-cancer (Corsia *et al*., 2002). Carob pods have antioxidant properties, apparently related to its phenolic compounds, which may by different mechanisms: act as an effective defense against reactive oxygen species including free radicals such as superoxide anion and hydroxyl radicals and non-free radical species such as hydrogen peroxide (Sebai *et al.*, 2013). Also, dietary fibers seem to be adequate in CPP (Sanchez-Zapata *et al.*, 2010). Carob germ flour is used as a potential ingredient in cereal derived foods for celiac people (Barroso *et al*., 2015; Fillet and Roulland, 1998). Several studies showed that CPP can be successfully incorporated into bakery products, since dietary fiber increase the volume, soft crumb and significantly prolonged the shelf life. It acts as a stabilizer in the dough system (Dadkhah *et al.*, 2012; Salem and Fahad, 2012; Yousef *et al.*, 2013). The unique cup-cakes making properties of wheat flour can be attributed mainly to the ability of its gluten proteins to form a viscoelastic network when mixed with water. The reduction of viscoelastic properties of a wheat flour dough after substitution by CPP increases cake making potential (Kocer *et al.*, 2007). To the contrary, El-Naggar *et al.* (2014) studied that effect of fenugreek flour on the dough blends. The replacement of wheat flour with fenugreek flour caused a decrease in extensibility of the dough and an increase in resistance to extension. In an attempt for improving the bakery products and significantly prolonging the shelf-life and retarding staling by using rich natural source of dietary fiber and polyphenols compound as carob pods powder with different ratios to make cupcakes which are classified as snack food. Evaluating these products chemically and physically, besides the sensory quality is the main factor in determining the acceptance and consumer preference for cupcakes.

2. Materials and methods

2.1 Materials

Wheat flour of 72% extraction was obtained from Agronomy Department, Faculty of Agriculture, Al-Azhar University, Assiut, Egypt. The carob pods (*Ceratonia siliqua*) were obtained from the local market. Fresh eggs, vanillin, baking powder, corn oil, sugar and dry skimmilk were obtained from local market. All chemicals and reagents were obtained from El-Gamhouria Trading Chemicals and Drugs Co., Assiut, Egypt.

2.2 Methods

2.2.1 Preparation of carob pods powder

The carob pods sample was kibbled and dried at $100^{o}C$ for two hours using an air oven then milled to a particle size of 500 µm (to pass a 100--mesh sieve), then re-milled to 150µm (to pass 32-mesh sieve) (Yousef and Alghzawi, 2000). The prepared carob pods powder was kept in polyethylene bags and stored in deep freezer at -18^{o}C until used. The dried carob pods powder were blending with soft wheat 72% extraction as sugar and /or fat replacers in creaming phase to replace 20, 40, 60, 80 and 100% of sugar and /or fat used in cupcakes formula as shown in Table (1).

2.2.2 Physical properties of carob pods

The physical of carob pods (lenth, width and weight) as well as seeds (weigh and count) were estimated while, the seeds/pods weigh ratio was calculated as described in AACC (2000).

2.2.3 Chemical composition of wheat, carob pods and wheat flour with different levels of carob pods powder used as a sugar or fat replacer

The chemical composition of wheat, carob pods and wheat flour with different levels of carob pods powder composite flour including crude protein, crude fat, ash, and crude fiber were determined according to official methods as described in A.O.A.C (1998). Nitrogen free extract (NFE) was calculated by difference (Ihekoronye and Ngoddy, 1985) and the energy of caloric value was calculated using Atwater conversion factors; 4.0kcal.for 1 g carbohydrates and protein while 9.0 kcal. for 1g lipid (FAO/WHO, 1973). These values were multiplied by each macronutrient factor and finally were summed to obtain the total caloric value.

2.2.4. Total phenolic compounds

Total phenolic compounds were determined using the method of folin-ciocalteu. A calibration curve was obtained using Gallic acid such a range of concentration solution (25 – 250 ppm). Data were expressed as mg Gallic acid equivalents (GAE/g) dry weight. Total phenolic compounds were determined according to method as described by Singleton *et al.*, (1999). The antioxidant activity was determined according to the method described by Lee, *et al.*, (2003). Briefly, the stack reagent solution was prepared by dissolving 22 mg of 2, 2 Diphenyl-1-picrylhydrazyl (DPPH) in 50 ml of methanol and stored at – 20^{o}C until use. The working solution was prepared by mixing 6 ml of stock solution with 100 ml of methanol to obtain an absorbance value of 0.8 ± 0.2 at 515 nm, as measured using a spectrophotometer. Extract solution of tested samples (0.1 ml) according to the method described by Zielijski, *et al.*, (2008) were vortexes for 30s with 3.9 ml of DPPH solution and left to react for 30 min. in the dark, and the absorbance was measured at 515 nm against a blank. Scavenging activity was calculated as follows:

$$\text{Antioxidant} = 100 \times \frac{\text{Absorbance of blank} - \text{absorbance of sample}}{\text{Absorbance of blank}}$$

Table (1): Formulation of cupcakes prepared using wheat flour with different levels of carob pods powder as a sugar and fat replacer.

Ingredient	Replacement levels										
	0%	20%		40%		60%		80%		100%	
	Control	A1	B1	A2	B2	A3	B3	A4	B4	A5	B5
Wheat flour	100	100	100	100	100	100	100	100	100	100	100
Sugar	50	50	40	50	30	50	20	50	10	50	-
Sugar replacer CPP	—	—	10	—	20	—	30	—	40	—	50
Egg (whole)	35	35	35	35	35	35	35	35	35	35	35
Dried skim milk	4	4	4	4	4	4	4	4	4	4	4
Baking powder	3	3	3	3	3	3	3	3	3	3	3
Vanilia	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Water	30	30	30	30	30	30	30	30	30	30	30
Fat	50	40	50	30	50	20	50	10	50	-	50
Fat replacer CPP	—	10	—	20	—	30	—	40	—	50	—

A: Fat replaced by carob pods powder (A1, A2, A3, A4, and A5). Control: Full-fat cupcake or full-sugar cupcake. B: Sugar replaced by carob pods powder (B1, B2, B3, B4, and B5).

2.2.5 Mineral matters

The ash residue obtained after having burned the sample weight at 550^{o}C was dissolved in HCL conc. and H_2O_2 on heating the solution during ten minutes. Filter the solution through Whatman filter paper and complete to the bottom flask with distilled water and then we evaluate the concentrations of the eventual elements presents in carob with Atomic Absorption Spectrophotometer. The mineral element concentrations are determined according to Official Method as described in A.O.A.C. (1998). The values are expressed on a dry matter basis.

2.2.6 Rheological properties

The characteristics of dough under investigation were measured by farinograph and extensograph apparatuses according to approved methods as described in A.A.C.C. (2000).

2.2.7 Cupcakes processing

Eleven of cupcakes formulations were prepared. One of cupcakes was used as standard control (full fat cupcake and full-sugar cupcake) and the other ten of cupcakes were divided into two parts; the first part was prepared by replacing a part of butter ingredient (20, 40, 60, 80 and 100%) with CPP. While the second part of cupcakes was prepared by replacing a part of sugar ingredient (20, 40, 60, 80 and 100%) with CPP. The quantities of the ingredients that were present in all the formulation are shown in table (1). The samples were identified as fat replaced by CPP (A1, A2, A3, A4 and A5) and as sugar replaced by CPP (B1, B2, B3, B4 and B5). Cupcakes were processed using the method followed in Department of Food Sciences and Technology Al-Azhar University, Assuit, Egypt. The dry ingredients were mixtured and transfer to mixing machine. Eggs were beaten by a whip and vanilin added to the beaten eggs. Butter and water were added to egg-vanilin mixture gradually with well beaten at low speed for 5 min., sugar was added with well beaten at low speed for 5 min. and dry ingredient were added to mixture gradually and mixer mixed at low speed for 5 min., scrape down, and then at medium speed for 2 min. Thirty grams of cake batter was weighed and place in paper baking cups in an aluminum muffin pans (cup size 7.6 x3.2cm, bottom diameter, 5.2) and was baked for 25 min. in a convection oven preheated to 180^{o}C. Five cakes of each formulation were baked. Cakes were kept at room temperature for 1h, then wrapped in plastic film and stored at -15^{o}C. For cupcakes application, sugar-and /or fat replacer (CPP), were added in the creaming phase to replace, 20, 40, 60, 80and 100% of sugar and /or fat used in cupcake formula.

2.2.7.1 Physical properties of cupcakes

Height, weight, volume and specific volume were measured according to Martinez – Cervera *et al.* (2011).

2.2.7.2 Determination of staling rate

The staling of cupcakes was measured by determination of Alkaline Water Retention Capacity (AWRC) by the method of Kitterman and Rubentholar (1971).

2.2.7.3 Sensory evaluation of the cupcakes samples

Sensory evaluation of the cupcakes samples were carried out by 10 panelists of judges on a 9 point hedonic scale (like extremely, like very much, like moderately, likes lightly, neither like nor dislike, dislike slightly, dislike moderately, dislike very much and dislike extremely). After that, their ratings were giving numerical values ranging from 9(for like extremely) to 1(for dislike extremely); for different parameters such as cells structure, grain, texture, crumb color and flavor as described by Lwe, (2010).

2.2.8 Statistical analysis

The data were statistically analyzed using the analysis of variance (ANOVA) and Duncan Multiple range test with significance level at $P \leq 0.05$ (Ihekoronye and Ngoddy, 1985).

3. Results and Discussion

3.1 Physical properties of carob pods

Physical properties of *Ceratonia siliqua* parts are found in Table (2). It illustrated that pod length was ranged between 16.00 and 22.00 cm, its width ranged from 2.55 to 3.00 cm and its weight reached from 18.17 to 23.33 g. On the other side, seed number, weight and seed weight /pod weight ratio were fall in the range of 8.00-14.00, 1.10-2.55 and 6.05-10.93% respectively. Similar results were concurrent with that found by Salem and Fahad, (2012) who stated that the length pod average recorded 15 cm, seed numbers average in each pod ranged 6-12 and the seed weight average was about 1.09-2.52 g/pod.

Table (2): Physical properties of carob pods.

Physical properties	Carob pods	Carob seeds
Pod length (in cm)	16.00 – 22.00	--------
Pod width (in cm)	2.55 – 3.00	--------
Pod weight (in gm)	18.17 – 23.33	--------
Seed Numbers	-------	8.00 – 14.00
Seed weight (in gm/pod)	-------	1.10 – 2.55
Seed weight/pod weight ratio%	-------	6.05 – 10.93

3.2 Chemical composition of materials

Data in Table (3) show the proximate composition of wheat flour WF (72% extraction) and carob pods powder flour (CPP). These results indicate that the main components of two types of flours were nitrogen free extract followed by crude fiber, protein, fat and ash respectively. From these results, detectable differences were observed between WF and CPP. Comparing between flour of WF and CPP, the data revealed that CPP had a higher content of fat (2.10 %), ash (3.33 %), crude fiber (18.58%), phenolic compounds (1800 mg GAE/100g), antioxidant activity (17.20 %), Ca (212.540 mg/100g), Fe (38.15 mg/100g), K (84.805 mg/100g), Zn (2.6 mg/100g) and Na (41.25 mg/100g). Generally, CPP exhibited higher phenolics content, antioxidant activity, crude fiber and iron than wheat flour. Hence, the obtained results ascertained the interest of utilizing flour of CPP as supplement in food formulation as bakery products such as cupcakes. The result is in good agreement with Yousef and Alghzawi (2000), Makris and Kefalas (2004), Khlifa *et al*. (2013) and Jambi (2015a). Additionally, carob pods powder flour is considered as a rich source of Ca, Fe and Na, while the trace element of Zn and Mg act as cofactors of antioxidant enzymes to protect the body from oxygen free radicals that are produced during oxidative stress. The data are in good agreement with Youssef *et al*. (2013). And also, is considered as a rich source of phenolic compounds act as appreciable antiradical and reducing agents. The findings are in good agreement with Makris and Kefalas (2004). Influence of carob pods powder on sensory characteristics of cupcakes produced from wheat flour with different levels of carob pods powder used as a sugar or fat replacer.

3.3 Sensory evaluation of cupcakes containing different levels of CPP compared with the standard control

Sensory evaluation of cupcakes containing different levels of CPP compared with the standard control is shown in Table (4). This was reflected in sensory quality scores for texture, grain, cells structure, flavor and crumb color with no statistically significant ($p \leq 0.05$) differences among treatments contained up to 40% CPP with replacing a part of butter ingredient (A2) or 60% CPP with replacing a part of sugar ingredient (B3), compared with the standard control for all organoleptic characteristics.

Table (3): Chemical composition of material, values are the mean of triplicate determinations.

Ingredient	Wheat flour 72%	Carob pods powder	LSD 0.05%
Protein	8.95±0.80	6.69±0.82	1.26
Nitrogen free extract (N.F.E)	88.90±0.45	69.3±0.42	10.46
Fat	0.80±0.05	2.10±0.17	0.83
Ash	0.55±0.06	3.33±0.15	0.86
Ca mg/100g	86.240±1.85	212.540±1.95	26.53
Fe mg/100g	8.005±0.82	38.15±1.04	15.14
Mg mg/100g	0.45±0.05	1.040±0.06	0.29
Zn mg/100g	1.020±0.11	2.060±0.14	0.74
K mg/100g	127.05±1.75	848.050±2.55	72.10
Na mg/100g	9.84±0.44	41.025±0.80	13.15
Crude fiber	0.80±0.06	18.58±1.04	7.34
Total phenolic (mg GAE/100 g)	381.5±1.43	1800.0±3.42	118.50
Antioxidant activity %	3.64±0.34	17.20±1.12	5.20

Table (4): Sensory evaluation of different cupcakes types produced from wheat flour with different levels of carob pods powder used as a sugar or fat replacer.

Trial	Type	Cells (10)	Grain (10)	Texture (10)	Crumb color (10)	Flavor (10)	Total score (50)
A*	C	8.85	8.65	9.20	9.30	8.40	44.40
	A1	8.80	8.80	9.35	9.55	8.82	45.35
	A2	8.83	8.65	9.40	9.55	8.85	45.28
	A3	8.70	8.30	8.90	9.10	8.30	42.9
	A4	7.4	7.55	7.85	8.75	7.80	39.35
	A5	6.8	7.15	7.05	8.10	6.90	36.00
B**	B1	8.95	9.30	9.50	9.45	8.85	46.05
	B2	8.85	9.20	9.45	9.30	8.60	45.4
	B3	8.80	9.05	9.35	9.10	8.50	44.8
	B4	8.55	8.50	9.10	9.00	7.25	43.40
	B5	7.80	8.20	8.80	8.70	7.15	41.65
L.S.D.		0.1544	0.35	0.30	0.25	0.45	1.50

Values are the mean of triplicate determinations and means in same column are calculated by different significantly ($p \leq 0.05$).

These results indicated that using CPP gradually increased the sensory characteristics with increasing the replacing levels for up to 40% level with replacing a part of butter and 60% with replacing a part of sugar and still acceptable until the highest level of replacing. The addition of CPP at different levels as a fat and/or sugar replacer in cupcakes gave more flavor and crumbly cupcakes with a more compact crumb, less aerated crumb. It may be due to relative increasing in starch gelatinization during baking not allows air bubbles to expand properly (Martinez-Cervera *et al.*, 2011). Thereupon, addition of CPP either as a fat and/or sugar replacer reduces the viscoelastic properties of wheat flour dough and increase cupcakes making potential. Cupcakes have a dry mouth feel at over 60% level. The crumb color darkened beyond 80%. Meanwhile, at 40 and 60% incorporation, all samples did not any adverse effect on the quality properties of cupcakes. Generally, acceptability of cupcakes with 40% (with replacing a part of butter) and 60% levels (with replacing a part of sugar) were quite similar to those with full-fat and/ or full- sugar cupcake samples, while cupcakes with over 60% level had significantly lower scores.

Table (5): Chemical composition of cupcakes produced from wheat flour with different levels of carob pods powder used as a sugar or fat replacer.

Trial	Type	Protein (%)	NFE (%)	Fat (%)	Ash (%)	Fiber (%)	Phenolic compounds (%)	Antioxidant activity (%)	C. V. kcal/100g
A*	C	8.80	79.10	9.5	1.80	0.8	350	3.34	437.1
	A1	8.75	79.85	7.5	2.10	1.8	510	4.87	421.9
	A2	8.70	80.45	5.80	2.55	2.5	675	6.45	408.8
	A3	8.70	81.4	4.10	2.85	2.95	845	8.07	397.3
	A4	8.73	81.62	2.90	3.00	3.75	1010	9.65	387.5
	A5	8.95	78.5	5.10	3.50	3.95	1650	15.77	395.7
B**	B1	8.84	77.43	10.0	1.83	1.90	525	5.01	435.08
	B2	8.82	76.21	10.25	2.12	2.60	700	6.69	432.37
	B3	8.80	74.89	10.75	2.57	2.99	860	8.22	431.51
	B4	8.75	73.21	11.50	2.84	3.70	1040	9.94	431.34
	B5	8.90	71.35	12.3	3.45	4.00	1700	16.24	431.7
LSD		0.07	2.54	2.55	0.8	1.25	318	6.50	15.10

Phenolic compounds: Expressed as Gallic acid equivalents mg GAE / 100g. C.V. kcal: Calories value per portion of 100 g.

These results are confirmed that obtained by Kocer *et al.* (2007) who found that sensory evaluation of experimental muffins with 50 % of the plan wheat flour substituted by polydexterose was significantly more desirable than the control muffins.

3.4 Chemical composition of cupcakes produced from the wheat flour with different levels of carob pods powder used as a sugar or fat replacer

The chemical composition of cupcakes made from wheat flour and CPP are shown in Table (5). Results shows that protein and caloric value decreased significantly ($p \geq 0.05$) with increasing CPP replacing level as well as either with replacing a part of fat or sugar ingredient. NFE content of prepared cupcakes were affected too much when compared to the standard cupcake, but at the higher replacement level, the NFE content of cupcakes seemed to be significantly ($p \geq 0.05$) lower than that of their full-fat or sugar cupcakes .A gradual increase in the NFE content was associated with the increase in CPP level used as a fat replacer in cupcakes. On the contrary, a gradual decrease in NFE content was associated with the increase in CPP level used as a sugar replacer in cupcakes. For fat content, a gradual decrease in the fat content was associated with the increase in butter replacement level. Meanwhile, a gradual increase in the fat content was associated with the increase in sugar replacement level. Whereas, ash, crude fiber, phenolic compounds and antioxidant activity increased significantly ($p \geq 0.05$) with increasing CPP level as well as also either with replacing a part of butter or sugar ingredient. Results indicated that the crude fiber, phenolic compounds and antioxidant activity are lower in wheat flour (72% extr.) than CPP. The values of phenolic compounds, crude fiber and antioxidant activity showed raise in supplemented flours with increasing the portions of added CPP, and the results indicated highly significant differences at $p \leq 0.05$ between WF and wheat flour with different levels of carob pods powder. This must be due to the relatively higher contents of these components comparing with wheat flour. These results agreed with those reported by Mohamed *et al.* (2004), Kocer *et al*. (2007) and Martinez–Cervera *et al*. (2011). Hence, CPP prepared on a bench scale, have been shown to have good nutritional properties when mixed with wheat flour during prepare of cupcakes.

Table (6): Effect of adding carob pod powder at different levels on the physical properties of cupcakes.

Trial	Type	Height cm	Weight gm	Volume Cm^3	Specific volume Cm^3/gm
A*	C	4.05	25.50	63.40	2.48
	A1	4.100	23.70	64.5	2.72
	A2	4.15	24.55	65.4	2.66
	A3	4.20	25.00	65.50	2.60
	A4	3.85	24.75	58.65	2.36
	A5	3.60	24.40	57.35	2.35
B**	B1	4.15	25.55	66.40	2.59
	B2	4.20	26.10	67.30	2.57
	B3	4.05	26.80	68.85	2.57
	B4	3.95	27.15	65.30	2.40
	B5	3.80	26.45	63.50	2.40
L. S. D.		0.301	1.345	2.143	0.145

Values are the mean of triplicate determinations and means in same column are calculated by different significantly ($p \leq 0.05$). A*: Fat replaced by carob pods powder (A1, A2, A3, A4, and A5). C: Full-fat cupcake and Full-sugar cupcake. B**: Sugar replaced by carob pods powder (B1, B2, B3, B4, and B5).

3.5 Influence of carob pods powder on the physical properties of cupcakes produced from wheat flour with different levels of carob pods powder used as a sugar or fat replacer

From the results in Table (6) it could be observed that fat and/or sugar replaced cupcakes weight was decreased with increasing the replacing level of CPP. Meanwhile, height was increased gradually with increasing the replacing levels of CPP until 60 % level then decreased at higher percent of CPP. This loss in height reflects the imbalance that changing the formulation entails. Also, volume and specific volume were increased gradually with increasing CPP replacing level until 40 % with replacing a part of butter ingredient and until 60 % with replacing a part of sugar ingredient, then decreased at the higher substitution levels of CPP. Incorporation of CPP up to 40 % level (with replacing a part of butter ingredient) and up to 60% (with replacing a part of sugar ingredient), caused a drastic increase in the averages volume and specific volume, although it had little effect on the averages cupcakes height and weight. Consequently, as the proportion of CPP increased (over than 60%) the cupcakes became than did those baked under 60%.These results are confirmed with those reported by Abd-El-Khalek (2007). No statistically significant ($p \leq 0.05$) difference was observed between the specific volume of the conventional cup cake and the tested cupcakes samples for up to60 % level of CPP rather with replacing a part of butter or sugar ingredient. Cake batter is a complex fat- in water emulsion composed of bubbles as the discontinuous phase and of egg sugar-water-fat mixture as the continuous phase in which flour particles is dispersed. Thermal setting of the cake is defined as the time at which the batter change from an emulsion to a porous structure (Kocer *et al.*, 2007), due to starch gelatinization together with protein denaturation (Mohamed *et al.*, 2011). Sugar in cake formulation results in a good air incorporation leading to a more viscous and stable foam (Mohamed, *et al.*, 2004). Sugar affects the physical structure of baked products by regulating gelatinization of starch. Delay in starch gelatinization during baking allows air bubbles to expand properly due to vapor pressure build up by carbon dioxide and water vapor before the cake sets. Sugar delays gelatinization of starch from 57 to 92^{o}C (Kocer *et al.*, 2007), which allows the formation of desired cake structure (Sudha *et al.*, 2007). Additionally, the major function of fat is to entrap air to the batter during mixing. When air start expanding, fat crystals adsorbed to the air-water interface melt and thereby release the fat- water interface for bubble expansion (Mohamed *et al.*, 2011). Generally, dietary fiber is known to cause excessive elevation of starch gelatinization temperature (90–97^{o}C) with protein denaturation temperature unaffected, causing premature egg protein denaturation. High gelatinization temperature caused the escape a part of the moisture that would function as a puffing agent (Martinez–Cervera *et al.*, 2011). Meanwhile, Barroso *et al.* (2015) mentioned that replacing of cocoa by carob pod powder in development of sandwich cookies improve their physicochemical and sensory characteristics. Similar results were found when part of the oil in a muffin formulation was replaced by peach dietary fiber (Mohamed *et al*., 2011).

Table (7): Effect of adding carob pods powder at different levels on alkaline water retention capacity (AWRC %) of stored cupcakes.

Trial	Type	Alkaline water retention capacity (AWRC %)						
		Fresh	After 5 days	R.C. (%)	After 10 days	R.C. (%)	After 15 days	R.C. (%)
A*	C	210	200	4.70	185	11.9	170	19.04
	A1	215	205	4.65	197	8.37	195	9.30
	A2	220	210	4.54	200	8.18	200	9.09
	A3	225	215	4.44	207	8.00	205	8.88
	A4	230	220	4.34	212	7.82	210	8.69
	A5	250	240	4.00	232	7.2	228	8.8
B**	B1	220	213	3.18	205	6.81	195	11.36
	B2	230	222	3.47	218	5.21	210	8.69
	B3	235	227	3.4	223	5.10	215	8.51
	B4	250	242	3.2	237	5.2	228	8.8
	B5	260	252	3.07	245	5.76	240	7.69

R. C. = rate of changes. A*: Fat replaced by carob pods powder (A1, A2, A3, A4, and A5). C: Full-fat cupcake and Full-sugar cupcake. B**: Sugar replaced by carob pods powder (B1, B2, B3, B4, and B5).

3.6 Influence of carob pods powder on the staling of cupcakes produced from wheat flour with different levels of carob pods powder used as a sugar or fat replacer

The staling of cupcakes was measured by determination of alkaline water retention capacity AWRC, and the data were presented in Table (7). It could be noticed that AWRC value was decreased as storage periods increased. Meanwhile, the results indicated that, AWRC value was relatively increased with increasing the CPP level comparing with the standard cupcakes sample. The rate of change was decreased with increasing the CPP level (with replacing a part of fat ingredient), while was drastic decreased with increasing the CPP level (with replacing a part of sugar ingredient). Although, results of standard cupcakes indicated that, AWRC value was decreased with increasing of storage periods. The accepted levels of CPP were 40% and 60% with replacing a part of fat and/or sugar ingredients respectively. This improvement might be due to the dietary fiber which considered surfactants, which slow of staling phenomena. Consequently, the greater moisture content can probably be linked to the water retention capacity of the soluble carob fiber. Increased moisture has been reported by Martinez-Cerevera *et al.* (2011) for muffin in which part of the fat had been replaced by cocoa fiber. These results are confirmed by Mohamed *et al.* (2004) who found that addition of orange albedo layer, carrot and apple pectin at different levels to wheat flour led to decrease the loss in hydration capacity values through the storage period and improved the bread quality and retarding the staling rate.

3.7 Influence of carob pods powder on the elastic properties of the cupcakes dough

From the results in Tables (8 and 9), it could be noticed that the accepted addition of CPP as a fat or sugar replacer on rheological properties of cupcakes were for up to40% or 60% level. It could be observed that the fat or sugar replaced cupcakes at 40 or 60% had lower (p≥0.05) mixing stability, resistance to extension, energy and proportional number than that of full-fat or sugar cupcake samples. Meanwhile, fat or sugar replaced cupcakes had higher (p≥0.05) water absorption, degree weakening, development time and extensibility than that of full-fat or sugar cupcake samples. These results confirmed by those obtained by Mohamed *et al.* (2004), who suggested that the weakening effect of foreign protein on wheat flour dough's was the result of a dilution of the gluten structure by the dietary fiber. This results in height, volume and specific volume, and subsequent has a positive effect on the other organoleptic quality attributes such as crumb color, grain and texture. While, Nassar *et al.* (2008) and Martinez–Cervera *et al.* (2011), who reported that the difference in water absorption is mainly caused by the greater number of hydroxyl groups which exist in the fiber structure and allow more water interaction through hydrogen bonding.

Table (8): Effect of the best addition of carob pods powder on the rheological properties of cupcakes by farinograph test.

Dough mixture Type	Water absorption (%)	Development time (min)	Stability time (min)	Degree weakening (BU)
Control	60	1.5	1.8	100
A2	65	1.7	1.5	110
B3	63	1.6	1.6	105

Table (9): Effect of the best addition of carob pods powder on the rheological properties of cupcakes by extensograph test.

Dough mixture Type	Resistance to extension R (BU)	Extensibility E (mm)	Proportional number R/E	Energy Cm^3
Control	350	125	2.8	35
A2	330	140	2.35	33
B3	340	130	2.61	32

From the previous data it could be noticed that additives increased extensibility, while resistance to extension, proportional number and energy compared with the control sample dough. The findings are in good agreement with those obtained by Salem *et al.* (2004) and El-Naggar (2014). Some investigations explored CPP as a readily available and inexpensive material for improving bakery products. However, data on carob pods antioxidant activity, related to its total phenolic compounds are very limited (Makris and Kefalas, 2004).

4. Conclusions

Results indicate that dietary CPP is an encouraging option for partial replacing fat and/or sugar ingredient in cupcakes formulation. The main advantages were that adding dietary CPP gave cupcakes lower weight and a more flavor, crumbly colour and texture beside, reduced the signs of staling during storage. Cupcake height, volume and specific volume affected by CPP replacing level to a similar extent emphasizing the influence of dietary fiber interference with the gelatinization mechanism on the expansion could be concluded that supplementation WF with CPP either used as a sugar- and fat replacer in cupcake formulations, improved the nutrient content and the rheological properties without adverse effects on the sensory attributes for up to 40 % level in the case of application the CPP as a fat replacer and for up to 60% level in the case of application the CPP as a sugar replacer in cupcakes.

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