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Evaluation of physicochemical, rheological and sensory properties of wafer cream by replacing cocoa powder with carob pod and chicory root powders

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Abstract

Wafer is a kind of wire-cut sandwich biscuit with soft, crisp and fragile texture that consists of two parts; bread wafer and cream. Wafer cream is a mixture of edible material like oil, sugar, milk powder, cocoa powder, flavour and lecithin. In the present work, the combination of carob pods powder and chicory root powder, as a substitute for cocoa powder in wafer cream, was investigated. Wafer cream was prepared in different amounts of carob powder and chicory root (0, 3.33, 6.67, 10, 13.33 and 20%) instead of cocoa powder. Physicochemical analysis (caffeine, total sugar, total fat, peroxide value, antioxidant activity, and colour), rheological properties (viscosity, torque and shear stress) and sensory evaluation (colour, odour, flavour, texture and total acceptability) were performed in different storage intervals (1, 30 and 60 days). Results were analysed by using design expert software and response surface method (RSM). The amount of caffeine significantly decreased in sample with 100% cocoa powder to sample with 100% carob pod powder and chicory root powder, while the amount of colour, sugar, and antioxidant activity increased. Other factors like peroxide value decreased in wafer cream samples with carob pod powder and chicory roots. Measurement of wafer cream rheological properties in different formulations were statistically significant. The colour, odour, flavour, texture and total acceptability of the formulated product were measured by the multiple comparison methods.

Introduction

The carob tree (*Ceratonia siliqua* L.) is native to Mediterranean and American countries such as Portugal, Turkey, Greece, Spain, Cyprus, Morocco, Mexico, Argentina and California (Batlle and Tous, 1997; Sahin *et al*., 2009; Salem and Fahad, 2012). Carob fruit shapes like a long bean (10 - 20 cm length and 1.5 to 2 cm width) and has some seed inside the pod. Colour of pods changes from green to brown upon maturity (Batlle and Tous, 1997; Gubbuk *et al*., 2010). The pods are rich in sugars, tannins, amino acids and minerals such as K, Ca, Fe, and Zn, that have important functions in our health (Ayaz *et al*., 2007). Carob has been used to displace cocoa due to it having low-fat and calorie, and hypo-allergenic (Vekiari *et al*., 2011). Carob also has many polyphenolic components which could decrease several illnesses such as cancer and heart problems due to its antioxidant activity (Salem and Fahad, 2012). Carob powder is one of the products made from the carob pod after roasting and milling. Another reason as to why carob powder is preferred by the food industry as a cocoa or chocolate substitute is that it is caffeine- and theobromine-free (Sahin *et al*., 2009).

Chicory (*Cichorium intybus* L.), from the Asteraceae family, is used in different parts of the world as salad and coffee substitute and even for treating illnesses (Sulas, 2004; Wani *et al*., 2011). Chicory roots consist of beneficial components such as coumarin, flavonoids and vitamins that could be used to prevent or cure diabetes, lack of sleep, and immunological and digestive illnesses. Inulin is one of these materials that is applied as low-calorie sugar or fat replacement in several foods (Wani *et al*., 2011). Besides these properties, chicory root has antimicrobial compounds which could inhibit certain Gram-positive, Gram-negative and even moulds (Koner *et al*., 2011).

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Cocoa (Theobroma cacao L.) is the fruit of the cocoa tree. In some South American, African, and Asian countries, cocoa are produced at an industrial scale. Forastero and Criollo are two kinds of cocoa in South America. Cocoa quality has a direct relationship with some genetics and environmental conditions like genotype, weather and harvesting method (Hussin, 2010). The main usage of cocoa is to make chocolate. Cocoa has polyphenols such as catechins, anthocyanins and proanthocyanidin that have antioxidant and health properties such as anti-carcinogenic, anti-thrombotic and anti-bacterial properties which could be used to prevent and treat sicknesses. However, cocoa also has anti-nutritive components like caffeine and theobromine which limits its usage (Hii *et al*., 2009). Therefore, in the present work, the physicochemical, rheological and sensory properties of wafer cream by replacing the cocoa powder with carob pod and chicory root powders were investigated. To the best of the authors' knowledge, this is the first work reporting the use of carob pod and chicory root powders as cocoa powder replacer in wafer cream.

Materials and methods

Materials

Carob pod powder was purchased from Incom A.S. Co. (Mersin, Turkey). Chicory root powder was purchased from Pioneer Chicory Co. (Gujarat, India). Sugar, milk powder and solid vegetable oil were purchased from a local market. Cocoa powder and lecithin were purchased from Flavorich Co. (Malaysia) and Cargill, Sao Paulo (Brazil), respectively. All chemicals and reagents were purchased from Merck (Germany).

Preparation of wafer cream

Firstly, all materials as listed in Table 1 were weighed. Then, oil was mixed with slow speed (speed 3, 1 - 2 min) and rapid speed (speed 7, 2 - 3 min) by hand mixer (Kenwood-KHM-919, 1 - 7 speeds, revolution: 700 - 1500 rpm). Next, sugar was added and mixed with rapid speed (speed 7, 1 - 2 min). Milk, cocoa, carob and chicory powder were then added and mixed (speed 5, 2 - 3 min). The different formulations are also listed in Table 1.

Determination of caffeine

Caffeine was determined from all samples following the method prescribed by the Institute of Standards and Industrial Research of Iran (ISIRI, 2003) and ultraviolet/visible spectrometry (UV-VIS UNICO, USA). Briefly, 50 mg caffeine was weighed, added to a 100 mL volumetric flask, and 100 mL chloroform solution was added to it. Standard solutions (0.03, 0.06, 0.09 and 0.1 ppm) were prepared by dilution, and their absorbance was measured at 276.5 nm with a UV/VIS spectrophotometry, and a standard curve was constructed. Next, 10 g sample was placed in a separating funnel and 5 mL potassium permanganate ($KMnO_4$) was added and shaken well. After 5 min, 10 mL reducing solution (5 g Na_2SO_3 + 5 g KSCN) was added and mixed well. Next, 1 mL phosphoric acid (H_3PO_4) and 1 mL NaOH solutions (25%) were added and mixed. Then, 50 mL chloroform solution was added. Following complete separation, 100 mL chloroform solution was added. Finally, absorbance of filtrate was measured at 276.5 nm. Tthe caffeine content of the samples were determined against the prepared standard curve (Ogah and Obebe, 2012; Dobrinas *et al*., 2014).

Determination of total sugars

The total sugar was determined following the Lane-Eynon method (Orphanos and Papaconstantinou, 1969; Tetik *et al*., 2010). The reducing sugars were determined after reduction at 67-70°C for 10 min by adding HCl or NaOH for adjusting pH. The concentration of reducing sugar was measured using Eq. 1 and Eq. 2:

Table 1. Formulations of cream wafer.

Formulation	Sugar (g)	Oil (g)	Cocoa powder (g)	Lecithin (g)	Milk powder (g)	Carob pod powder (g)	Chicory root powder (g)
T0	45	30	20	3	2	0	0
T1	45	30	0	3	2	20	0
T2	45	30	10	3	2	0	10
T3	45	30	0	3	2	10	10
T4	45	30	0	3	2	0	20
T5	45	30	3/33	3	2	3/33	3/33
T6	45	30	3/33	3	2	13/33	3/33
T7	45	30	6/67	3	2	6/67	6/67
T8	45	30	10	3	2	10	0
T9	45	30	3/33	3	2	3/33	13/33

Non-reducing sugar = Total reducing sugar contents – reducing sugar content (Eq. 1)

Total sugar concentration = Reducing sugar + non reducing sugar (sucrose) (Eq. 2)

Determination of total fat

The total fat of samples was analysed following the method prescribed by AOAC (1990), ISIRI (2010), Ying and Gui (2012) and Racolta *et al*. (2014). Briefly, 15 - 20 g sample was weighed in a thimble and placed in a Soxhlet set with round bottom flask. Next, petroleum ether solvent was added to the flask. The Soxhlet was set to boil for 6 h, after which the flask was rotated to evaporate the solvent. Finally, the flask was placed in an oven at 102°C. After cooling the flask in a desiccator, the flask was weighed and the fat content was determined using Eq. 3:

$$\text{Total fat content (\%)} = \frac{100\ (W_2\text{-}W_1)}{M} \quad \text{(Eq. 3)}$$

where M = sample weight, W_2 = weight of flask after extraction, W_1 = weight of flask before extraction.

Determination of peroxide value

Briefly, 5 g sample was weighed into a 250 mL Erlenmeyer flask, and 30 mL mixture of acetic acid and chloroform solvent was added into the flask and mixed well. Then, 0.5 mL saturated potassium iodide solution was added and incubated for 1 min in the dark. Next, 30 mL deionized water and 0.5 mL starch solution were added. Finally, 0.01 N $Na_2S_2O_3$ was titrated until the deep blue colour disappeared and changed to milky appearance (AOAC, 2000; 2006; IFRA, 2011). The peroxide value was determined using Eq. 4:

$$\text{Peroxide value (meq/kg)} = \frac{\text{S - B} \times \text{N thiosulfate} \times 1000}{\text{Weight of sample)}} \quad \text{(Eq. 4)}$$

where S = titration of sample, B = titration of blank

Determination of antioxidant activity with DPPH radicals

The antioxidant capacity was determined following the method prescribed by Shad *et al*. (2013) which measured the free radical-scavenging effect on 1, 1-diphenyl-2-picrylhydrazyl (DPPH) radical (Torun *et al*., 2013). Briefly, 1 g sample was mixed with 10 mL solvent (40% water + 30% ethanol + 30% methanol) and shaken with a shaker. Different concentrations of extract (25, 50 and 80 µL) were prepared and mixed with 2 mL DPPH. The absorbance was recorded at 517 nm (UNICO-UV/VIS spectrophotometer) after 30 min (El Hajaji *et al*., 2011; Shad *et al*., 2013; Torun *et al*., 2013). The percent inhibition of DPPH radical was calculated using Eq. 5:

$$\text{DPPH inhibition (\%)} = 100 \times [(Abs_0 - Abs_{30})/Abs_0] \quad \text{(Eq. 5)}$$

where Abs_0 = observance of control, Abs_{30} = absorbance of sample after 30 min.

Rheological measurements

The rheological properties (viscosity, torque and shear stress) of wafer cream samples were determined using a Brookfield Viscometer (Model: DVII+Pro). Briefly, sample was poured into 100 mL beaker to the spindle mark. Then, by using LV-4 (64) spindle it was measured at 1 - 50 rpm. Results were recorded at each rpm, three times at 23°C (Cool *et al*., 2011).

Determination of colour

The colour of the wafer cream samples was analysed by using a Minolta, CR-300, JP colorimeter. *L**, *a** and *b** indicated lightness, redness and yellowness, respectively (Akkaya *et al*., 2012).

Sensory evaluation

The sensory evaluation was conducted by semi-trained panellists (12 judges) for colour, taste, odour, texture, and general appearance. The panellists were asked which of the samples in comparison to control were better, worse or similar. In this method, samples better than control scored nine, samples worse than control scored one, and samples similar to control scored five (Yousif and Alghzawi, 2000).

Statistical analysis

The obtained data were analysed using the design expert software (2008), and response surface methodology (RSM) was used to assess the independent variables (cocoa, chicory and carob powder) on the rheological, chemical and sensory properties.

Results and discussion

Caffeine

Different kinds of plants, foods and drinks have caffeine, and these are daily consumed by the population (Butt *et al*., 2011). Statistical analysis showed a significant difference ($p < 0.05$) in caffeine content among wafer cream samples formulated with different amounts of carob pod, cocoa and chicory root powders. Control yielded the highest amount of caffeine. Formulation 7 (equal amount of carob, cocoa and chicory powder) yielded the lowest caffeine content.

Butt *et al*. (2011) evaluated the effect of decaffeination on nutritional and antioxidant status of different coffee brands. They studied four coffee groups: T0 (instant coffee), T1 (coffee beans), T2 (decaffeinated coffee), T3 (commercial caffeinated ground coffee) and T4 (commercial decaffeinated ground coffee). Caffeine contents were 11.8, 12.5, 0.41, 12.3 and 0.36 mg/g, respectively. Ramli *et al*. (2001) determined methylxanthine and polyphenol levels in 32 cocoa and chocolate products by HPLC, and found that caffeine and theobromine levels were 0.62 - 1.14 mg/g and 0.026 - 0.153 mg/g, respectively. Theobromine and caffeine contents in chocolate coating were 0.82 and 0.07 mg/g, respectively. They also noted in local milk chocolate to be 0.72 mg/g and 0.04 mg/g in comparison with local dark chocolate with 0.85 mg/g and 0.06 mg/g. As with imported chocolate, the theobromine and caffeine levels were 1.05 mg/g and 0.12 mg/g of dark chocolate; 0.76 mg/g and 0.04 mg/g in milk chocolate; and 0.74 mg/g and 0.03 mg/g in white chocolate, respectively. Salem and Fahad (2012) substituted cacao by carob pod powder in milk chocolate manufacturing, and showed that caffeine content decreased in samples containing 100% carob in comparison to control (100% cocoa). Caffeine contents in milk chocolate samples manufactured by different amounts of carob pod powder were, control (carob free): 2720.26 mg/kg, 25% carob powder: 2382.44 mg/kg, 50% carob powder: 1059.16 mg/kg, 75% carob powder: 740.678 mg/kg and 100% carob powder: 0 mg/kg. Craig *et al*. (1984) evaluated the caffeine and theobromine levels in cocoa and carob products; these two components were 0 - 0.067 mg/g and 0.504 mg/g.

Total sugars

Statistical analysis showed that adding carob pod, cocoa and chicory root powders to wafer cream samples significantly affected ($p < 0.05$) the total sugar contents. Formulation 1 yielded the highest amount (54.61%) of total sugar, and control yielded the lowest (45.01%). It was found that samples with carob pod powder had more sugar content in comparison with other samples without or less carob pod powder.

According to El Batal *et al*. (2016) that studied the sugar composition and yield of syrup production from the pulp of Moroccan carob pods, total sugar content varied between 31.5 and 50.1 g/100 g (w/w %) of dry pulp in populations of Agadir and Essaouira, respectively. Ayaz *et al*. (2007) determined the chemical composition of the Anatolian carob pods: sugars, amino and organic acids, minerals and phenolic compounds. They found that the ethanolic extracts had three major sugars; sucrose, glucose and fructose (437.3, 395.3 and 42.3 mg/g dry weight), whiles total sugars were 87.54% of the total dry weight of the extracts. Vekiari *et al*. (2011) studied the variation of quality characteristics in Greek and Turkish carob pods during fruit development. It was found that the sugar content in three growth stages (1st, 2nd and 3rd) were for Greek Fleshy (23.1, 56.4 and 38% dry matter), Greek Wild (18.1, 39.2 and 45.6% dry matter), and Turkish Fleshy (27, 0 and 37.7% dry matter), respectively. Milala *et al*. (2009) carried out composition and properties of chicory extracts rich in fructans and polyphenols, chicory extract (peels, roots, leaves and seeds) had 26.1, 25, 63 and 36 % dry matter of total sugar. Similar results were found by Shad *et al*. (2013) in relation to total and reducing sugars in different parts (root, steam, leaves and seed) of chicory. Their results showed that the total sugars were (2.03, 2012, 4.50 and 3.05) and reducing sugars were (0.13, 0.24, 0.23 and 0.44). Bulca (2016) obtained a similar result for some properties of carob pod and its use in different areas including food technology. Her results showed that carob pod is rich in sugars (48 - 72%). Ibrahim *et al*. (2015) studied the quality characteristics of rice biscuits sweetened with carob powder, and observed that carob powder had total carbohydrate (82.56%) and total soluble sugar (54.2%), while total carbohydrate was 60.53 - 62.85% among different samples of biscuit.

Total fat

Fat is one of the factors which could affect material combination in formulation and product taste, even in peroxide value changes. Statistical analysis showed that adding carob pod, cocoa and chicory root powders to wafer cream samples significantly ($p < 0.05$) affected the total fat. Control yielded the highest fat content (32.07%) while Formulation 3 the lowest (30.06%).

According to Yousif and Alghzawi (2000) that

worked on processing and characterisation of carob powder, crude fat in roasted carob pod and cocoa powder was 0.74 and 22.9%. Mahtout *et al*. (2016) highlighted that carob supplementation affected kefir quality and antioxidant capacity during storage, and that concentration of different parts of carob (pod, pulp and seed) yielded 2.65, 1.63 and 2.26 lipid (g/kg), respectively. Salem and Fahad (2012) found that carob pod had 4.8% crude fat, and milk chocolate manufactured by different amounts of carob pod powder (0, 25, 50, 75 and 100%) had 29.66, 28.10, 26.99, 26.61 and 24.09% fat, respectively. Ibrahim *et al*. (2015) studied the quality characteristics of rice biscuits sweetened with carob powder, and observed that carob powder had crude fat (1.07%), and this amount was 27.41 - 28.77% in different samples of biscuit. Herken and Aydin (2015) reported that the use carob flour (0, 5, 10, 15 and 20%) could increase the fat content in several samples of tarhana (4.17, 4.32, 4.08, 4.25 and 4.12%) in comparison with carob flour with 3.98% fat. Racolta *et al*. (2014) characterised the confectionery spreadable creams based on roasted sunflower kernels and cocoa or carob powder, and noted that control had the highest content of fat (33.98%) and the other two samples consisted of carob and cocoa had similar values (32.42% and 31.98%). Jurgoński *et al*. (2011) reported that the amounts of fat in chicory root and carob pod were 1.73, 4.80%.

Peroxide value

Peroxide value is one of the other parameters which could change during storage time. Changing the peroxide value has direct relation to the amount of fat, the type of fats and oxygen level. The peroxide value determined after 1, 30 and 60 storage days on the fat extraction of samples is shown in Figures 1a, 1b and 1c. Statistical analysis showed insignificant difference on the 1st day ($p > 0.05$), but on 30th and 60th storage days, there was significant difference ($p < 0.05$). Results showed that adding carob pod and chicory root could be the reason of peroxide value decrease in samples containing these two substances. On the 1st day, Formulation 7 had the lowest peroxide value; on the 30th day, Formulation 1 had the lowest peroxide value; and on the 60th day, Formulation 9 had the lowest peroxide value.

Ibrahim *et al*. (2015) determined the peroxide value of rice biscuits with carob powder (0, 20, 25, 30, 35 and 40%) during the storage period at room temperature (25°C) for 0 to 6 months. Their results showed the peroxide value to be 0.11 to 0.16 meq/kg fat at zero time for all formulas. The peroxide value of control after 3 to 4 months was 7.3 - 10.9 meq/kg fat. After 6 months for each rice biscuit with 35% and 40% of carob powder, peroxide value were 13 and 20 meq/kg fat, respectively, while rice biscuits having 20, 25 and 30% were 9.25, 7 and 8.02 meq/kg fat, respectively. El-sherif and Tolba (2011) extracted and identified the natural antioxidants from liquorice (*Glycyrrhiza glabra* L.) and carob and their application in El-Mewled El-Nabawy sweets (sesames and folia), and calculated the peroxide value during storage days (0 - 6 days). Their results showed that the lowest peroxide values were in sesame sweets with sweet + 6 g liquorice powder (0.76 meq/kg fat) and folia sweets with sweet + 7.5 mL liquorice extract (1.28 meq/kg fat) at zero day. The highest peroxide value in both sweets were 2.01 and 2.85 meq/kg fat, respectively. The peroxide values of control, sesame sweets and folia sweets of 3 to 4 days were 4.54 - 6.83 and 5.92 - 7.01 meq/kg fat, respectively. After 6 storage days, sesame sweets peroxide value was 6.36 - 9.38 meq/kg fat (sweet + 7.5 mL liquorice extract and sweet + 5 mL carob extract), but in folia sweets the peroxide value was 5.12 - 9.90 meq/kg fat (sweet + 7.5 mL liquorice extract and control).

Antioxidant activity with DPPH radical

Free radicals can cause oxidative stress. One way to prevent this is through the usage of antioxidant material or adding materials with antioxidant properties from plants such as carob and chicory powder. In fact, synthetic and natural antioxidants have been used to delay the oxidation process in several foods (Bulca, 2016). In the present work, the antioxidant activity was determined after 1, 30 and 60 days of storage. Results showed that adding carob pod and chicory root could increase antioxidant activity in samples. Statistical analysis did not show a significant difference ($p > 0.05$) on the 1st day. The highest antioxidant on the 1st day was for Formulation 1 only with carob pod (6.43 µg/mL), but on 30th and 60th day, statistical analysis showed significant difference ($p < 0.05$). The highest antioxidant was from Formulation 6 on the 30th day (14.15 µg/mL) and Formulation 5 on the 60th day (12.14 µg/mL).

Rajabi Gol *et al*. (2014) and Shad *et al*. (2013) noted that roots, seeds and aerial parts of chicory had antioxidant activities. Furthermore, Ayaz *et al*. (2007), Rababah *et al*. (2013) and Torun *et al*. (2013) noted that carob also contains high amounts of polyphenolic compounds, antioxidant and free radical-scavenging compounds. Jambi (2015) studied the effect of roasting on polyphonies content of carob powder, and showed that carob powder had 186.07 mg/100 g (total phenols), 18.66 mg/100 g (total carotenoids), 706.67 mg/100 g (total tannins) and 95.82% (antioxidant

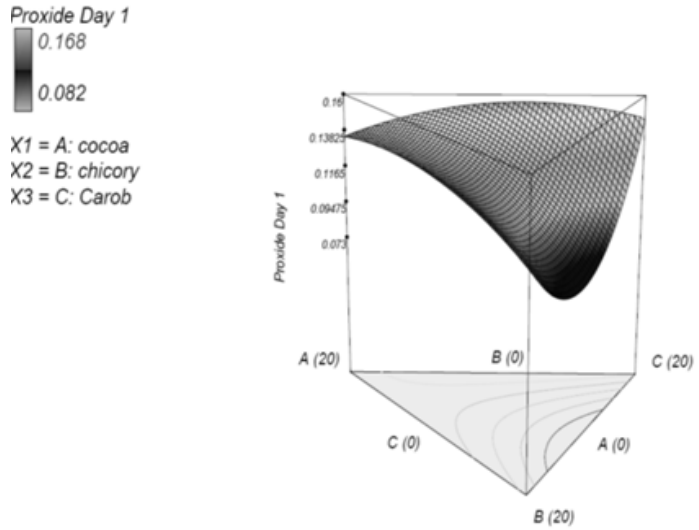

Figure 1a. Peroxide value response surface for wafer cream (1st day). AB/AC/BC shows no significant effect on the peroxide value ($p > 0.05$). A: cocoa, B: chicory, C: carob.

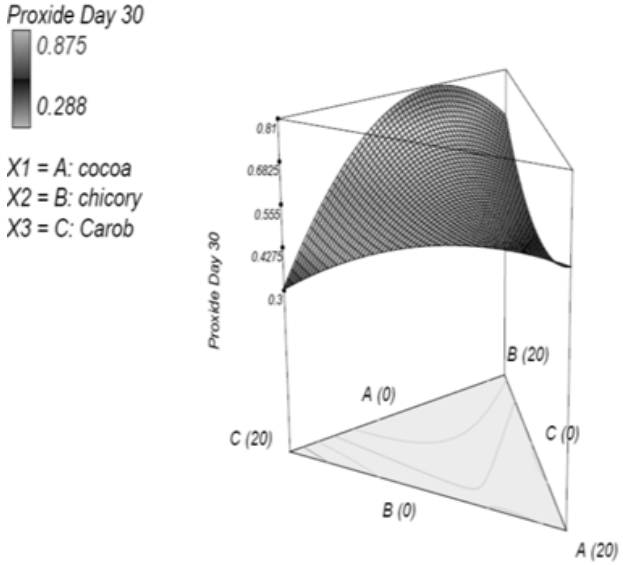

Figure 1b. Peroxide value response surface for wafer cream (30th day). AB/AC/BC shows significant effect on the peroxide value ($p < 0.05$). A: cocoa, B: chicory, C: carob.

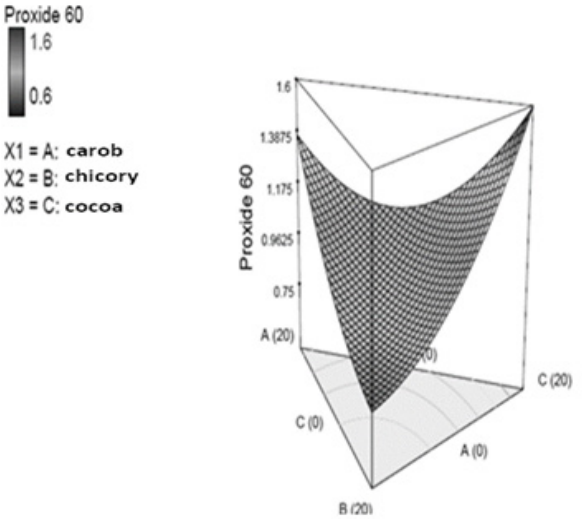

Figure 1c. Peroxide value response surface for wafer cream (60th day). AB/AC/BC shows significant effect on the peroxide value ($p < 0.05$). A: cocoa, B: chicory, C: carob.

activity) before roasting, and 102.89 mg/100 g (total phenols), 11.93 mg/100 g (total carotenoids), 643.43 mg/100 g (total tannins) and 27.09% (antioxidant activity) after roasting. According to Mahtout *et al*. (2016), antioxidant activities increased during storage of kefir supplemented with carob seed (highest) and crude pulp (lowest) for 14 days. Ibrahim *et al*. (2015) pointed out that the antioxidant activity and total phenol in carob powder to be 1256.6% and 84.9 mg/100 g, respectively, and 0.78% and 659.71 mg/100 g, respectively, in biscuit with 35% carob powder.

Rheological properties

Numerous parameters such as particle size, distribution, size, crystallisation of fat during processing, the amount of protein, sugar and materials like milk powder, lecithin and whey protein, can affect the viscosity and rheological properties. Cocoa, carob and chicory have a considerable amount of protein, soluble and non-soluble fibre, sugar and fat that can change the viscosity of wafer cream (Cool *et al*., 2011). Statistical analysis showed a significant difference ($p > 0.05$) in the viscosity of wafer cream samples. Based on Table 2, the highest viscosity, torque and shear stress values were obtained from Formulation 8 containing 10% cocoa powder + 10% carob powder, while the lowest was from Formulation 1 containing 20% carob powder. It was found with increasing cocoa powder, the rheological properties increased, and with increasing carob pod powder, the rheological properties decreased.

Table 2. Rheological properties of different cream wafer formulations.

Formulation	Viscosity* (Pa.s)	Torque (%)	Shear Stress* (Pa.s)	T (°C)
T0	10.08	68.70	5.04	23
T 1	6.72	45.80	3.36	23
T 2	8.23	56.10	4.12	23
T 3	7.38	50.30	3.69	23
T 4	7.72	52.60	3.86	23
T 5	9.13	62.20	4.56	23
T 6	8.32	56.70	4.16	23
T 7	9.11	62.10	4.56	23
T 8	10.36	70.60	5.18	23
T 9	8.10	55.20	4.05	23
σ	± 4.281559	± 29.177	± 2.139643	

Joel *et al*. (2013) studied the production and quality evaluation of cocoa products, and noted that the percentage of fat, protein, curd fibre, ash and carbohydrate in different cocoa powders were 10.5 - 12.65%, 6.80 - 9.55%, 1.06 - 2.64%, 5.32 - 6.41% and 61 - 62.47%, respectively. Yousif and Alghzawi (2000) pointed out that the carob pod had fat (0.74%), protein (5.82%), curd fibre (7.24%), ash and total sugars (38.7%). Cool *et al*. (2011) noted that the addition carob pod to pretzel cover as dark and milk chocolate replacement could increase the viscosity, since dark chocolate had always been less viscous than milk chocolate. However, despite the mixing speeds, it was more viscous in comparison with carob. On the other hand, with increasing speed in samples with carob pod, viscosity decreased from 2413.3 to 1066.7 Pa.s. Shad *et al*. (2013) demonstrated that the amount of water-soluble and salt-soluble proteins in chicory roots were higher than other parts, and that these could change viscosity. El-Kholy (2015) found that adding carob pod powder (0, 20, 40 and 60%) significantly ($p < 0.05$) increased viscosity, plastic viscosity and consistency index during the aging period (5 ± 1°C and 24 h), in ice cream. The increase in viscosity could be due to high levels of fibre, which also affected the water holding capacity. Herken and Aydin (2015) reported that the addition of carob flour (0, 5, 10, 15, and 20%) to tarhana soup decreased the viscosity and yield stress of the samples.

Colour

Significant differences ($p < 0.05$) were observed between colour parameters (L^*, a^* and b^*) of the wafer cream sample. The results of all the formulations showed that Formulation 1 (20% carob pod powder) yielded the highest, while Formulation 2 (10% chicory root powder + 10% cocoa powder) the lowest L^* values. Formulation 1 yielded the highest, while Formulation 4 (20% chicory root powder) yielded the lowest a^* values. Again, Formulation 1 yielded the highest, while Formulation 2 yielded the lowest b^* values.

Similar results were obtained by Rosa *et al*. (2015) that used carob flour as a cocoa powder substitute in cakes made with soy and banana flours. Cake with 100% cocoa powder had the highest L^* value in comparison with the other samples. Cake with 100% carob flour had the highest a^* value, and cake with 100% cocoa powder had the lowest a^* value. 25% carob flour + 25% cocoa powder and 75% carob flour + 25% cocoa powder had the highest and lowest b^* values, respectively. Herken and Aydin (2015) used carob flour (15 - 20%) to produce tarhana. They found out that carob flour had lower L^* value and higher a^* and b^* values in comparison with wheat flour. Also, their results showed that increasing level of carob flour could increase a^* and decrease b^* values. Yousif and Alghzawi (2000) demonstrated that the non-roasted carob powder in

comparison with roasted carob powder and cocoa powder had lighter colour. On the other hand, they showed Maillard reactions and caramelisation could change the colour of these two products. They also concluded that roasted carob powder was the same as cocoa powder. Ferreira *et al*. (2016) studied the physical properties of cakes with chicory root flour used as a source of inulin, and showed that increasing content of chicory flour (5 - 10%), decreased the L^* value. For a^* values, cake samples with 5% chicory root flour and 10% chicory root flour were higher than control.

Sensory evaluation

Statistical analysis showed that adding carob pod, cocoa and chicory root powders to wafer cream samples significantly affected ($p < 0.05$) the sensory parameters.

For colour, Formulation 4 scored the highest. Salem and Fahad (2012) found that adding carob pod powder instead of cocoa seed increased the sensory properties of milk chocolate products.

For odour, Formulation 5 scored the highest score, while Formulation 3 the lowest. According to Ibrahim *et al*. (2015), replacement of rice flour with 35% carob powder enhanced the sensory properties such as taste, texture and odour in rice biscuits.

For flavour results, Formulation 8 scored the highest, while Formulation 1 the lowest. According to Ibrahim *et al*. (2015), with increasing carob pod 0 - 40%, the flavour scores increased. According to Rababah *et al*. (2013), no significant differences were detected among grape juice and carob particle and powder carob juices in aromatic characteristics (caramelised and fermented). They also showed that due to the high amounts of carbohydrate and tannins in carob pods, particle and powder carob juices significantly differed from grape juice with sweet.

For texture, Formulation 4 scored the highest, while Formulation 1 scored the lowest. El-Kholy (2015) explained that carob pod had no negative effect on the texture and ice cream shapes. Barroso *et al*. (2015) evaluated chemical and sensory of sandwich cookies made with carob powder, and noted that sandwich cookies only with carob powder had lower texture score in comparison with sandwich cookies containing textured soy protein and sandwich cookies only with cocoa powder. Rosa *et al*. (2015) pointed out that there were no significant differences between cake textures containing up to 75% carob flour.

For total acceptability, Formulation 8 scored the highest, while Formulation 4 scored the lowest. El-Kholy (2015) investigated the impact of carob pod powder on the physical and sensory properties of ice cream, and noted that the replacement up to 24% carob pod powder had significant ($p < 0.05$) result and increased the scores for flavour and total acceptance as compared to control.

Conclusion

In the present work, carob pod and chicory root powder were used as cocoa powder replacement in wafer cream. Results showed that carob pod and chicory root had a positive effect on physicochemical, rheological and sensory properties of the formulated wafer creams. The lowest caffeine content was found in sample having equal amount of carob pod, chicory root, and cocoa powder. In samples with carob pod, the highest amount of sugar was noted; antioxidant activity was also the highest. On the other hand, with increasing cocoa powder, rheological properties increased, and with increasing carob pod powder, rheological properties decreased. Formulation 1 was selected as the best sample in physicochemical properties, while Formulation 8 was selected as the best sample in sensory evaluation. In recent years, the consumption of cocoa-based and coffee-based products such as chocolates, desserts and biscuits is increasing among people especially kids. Since caffeine can affect health and cause illness, it is thus necessary to substitute cocoa with caffeine-free plant-based such as carob pod and chicory root.

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