Effect of adding carob molasses on physical and nutritional quality parameters of sesame paste

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Abstract This study focused on the formulation of food products, based on sesame and carob. The possibility of developing blends from sesame paste and carob molasses, using molasses concentrations of 30, 40 and 50%, at 60, 70 and 80Brix, respectively, has been studied. The blend prepared with 50% carob molasses at 60Brix was found to be the most acceptable product, according to a sensory acceptability test. Sesame paste, supplemented with carob molasses, was evaluated for physical quality (oil separation, colour and texture) and nutritional composition (moisture, sugar, protein, fat, ash and polyphenols). Physical analysis showed that the addition of carob molasses to sesame paste improved its emulsion stability, changed its colour from beige to brown and modified its texture from fluid to solid. Nutritional analysis proved that mixing sesame paste with carob molasses provided a natural product, characterized by interesting nutritional value (protein: 16.97 g/100 g fry matter, fat: 12.05 g/100 g fry matter and sugar: 9.34 g/100 g fry matter), arising from the constituents of the two ingredients. Thus, the developed blend could offer a promising nutritious and healthy foodstuff to consumers.

Keywords Sesame paste · Carob molasses · Blend · Sensory acceptability · Physical quality · Nutritional composition

Introduction

Sesame plants (*Sesamum indicum* L.) are cultivated in several countries, such as India, Sudan, China and Burma, which are considered as the major producers. Sesame seeds have been widely used in the food industry, including paste production (Elleuch et al. 2007). Sesame paste, called also tahin or tehineh, is produced from hulled, roasted and milled sesame seeds. It represents a natural source of energy, due to the fact that it is rich in lipids and proteins. It is used in the preparation of some local foods in the Middle East, such as chick peas (hummus tehineh) and halaweh (sweet tehineh) (Abu-jdayil et al. 2002). It is also used in the formulation of a traditional sweet food, containing natural sweeteners, such as honey and molasses (Razavi et al. 2007). Sesame paste/molasses blend is widely consumed in Turkey (known as tahin/pekmez blend) and Iran (known as Halwa-Ardeh), especially in winter, due to its high nutritional value (Arslan et al. 2005; Razavi et al. 2007). High protein and lipid contents of tahin, mixed with high sugar and mineral containing pekmez (molasses-like syrup), might offer a promising nutritious and healthy alternative to consumers (Alpaslan and Hayta 2002). In the Turkish food market, tahin and pekmez are sold separately and the blend is homemade, with a ratio of tahin to pekmez determined by consumers (Arslan et al. 2005). Consumer acceptance of such products depends mainly on their spreadability on another material, such as bread, which has a direct relationship to food structure. Sesame paste/fruit molasses blends can be regarded as an oil-in-water

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emulsion: the paste contains the oil phase (dispersed phase), while the molasses contains the water phase (continuous phase) (Alpaslan and Hayta 2002).

Carob trees (*Ceratonia siliqua* L.) are cultivated or naturally grown mainly in Mediterranean countries, including Tunisia, Algeria, Morocco, Spain, Portugal, Italy, Turkey and Greece. The fruit, also called carob pod, is generally made of 80–90% pulp and 10–20% seeds by weight. It has an extensive use in the production of carob derivatives, mainly gum, powder and molasses (Tounsi and Kechaou 2017). Carob molasses is a juice concentrate (60–80°Brix) characterized by a brown to dark colour. It is prepared by water extraction from the pod or the pulp and concentrated by boiling in open vessels or under vacuum (Sengül et al. 2007; Tounsi et al. 2017). It is a naturally nutritious food, with high amounts of sugars (sucrose, glucose and fructose), minerals (potassium, calcium, magnesium, phosphorus and iron) and organic acids (citric acid) (Özcan et al. 2007; Sengül et al. 2007; Tetik et al. 2010, 2011). It is also a natural source of bioactive compounds, as polyphenols, 5-hydroxymethylfurfural and D-pinitol, endowed with biological activities and health-promoting effects, such as glycemic regulation (Dhaouadi et al. 2014; Tetik et al. 2010, 2011; Toker et al. 2013).

There are several studies about the rheological properties of blends developed from sesame paste and fruits molasses made of grapes (Alpaslan and Hayta 2002; Arslan et al. 2005) or dates (Razavi et al. 2007). However, there is no information about the preparation of sesame paste/carob molasses blends. Therefore, the objectives of this study were to prepare blends from sesame paste and carob molasses and to investigate the effect of adding carob molasses on the physical and nutritional quality parameters of sesame paste.

Materials and methods

Carob molasses preparation

Three samples of carob molasses with different soluble solids contents (60, 70 and 80°Brix) were prepared, according to a traditional process (Fig. 1). Carob pods, purchased from the local market (Sfax, Tunisia), were first washed in water and then fragmented to prepare a juice by hot water extraction. When the water started to boil, the carob fragments were added at a ratio of 1:4 (g:ml), and the mixture was kept boiling for 30 min. After extraction, the juice was filtered with a filtering cloth (muslin) and then boiled to obtain three concentrations (60, 70 and 80°Brix).

Fig. 1 General diagram of carob molasses processing

Sesame paste preparation

Sesame paste (tahin) was made on industrial scale in the Confiserie TRIKI-Le Moulin factory (Sfax, Tunisia), according to the manufacturing diagram presented in Fig. 2. Tahin was prepared by grinding hulled and roasted white sesame seeds, imported from the Sudan.

Molasses/paste blend preparation

Nine blends were prepared by adding each molasses sample to the sesame paste at three ratios (30, 40 and 50%, w/w) as shown in Fig. 3. The molasses levels in tahin were selected by the industrial staff to represent levels that consumers would find acceptable. The blends were mixed with a stand mixer (KRUPS, France), equipped with a

Fig. 2 Diagram of sesame paste production at Confiserie TRIKI-Le Moulin (Sfax, Tunisia)

kneading hook, at a constant speed until the formation of a homogeneous paste. The samples were then scooped into food plastic containers and analyzed.

Product acceptability test

The acceptability of the sesame paste/carob molasses blends were conducted in the sensory analysis laboratory of Confiserie Triki—Le Moulin (Sfax, Tunisia). The room was equipped with isolated sensory booths. A semi-trained panel of 12 women and men, aged 25–35 years, participated in the evaluation. The samples were served to the panelists in a random order. Each sample was coded with

randomly three-digit numbers. The panelists were asked to give scores for evaluated seven attributes (appearance, colour, odour, taste, texture, spreadability and overall acceptability), based on a 5-point hedonic scale ranging from 1 (disliked extremely) to 5 (liked extremely). The panelists were instructed to rinse their mouths between samples with water.

Physical analyses

Colour parameters

Colour measurements were carried out with a colourimeter (Konica Minolta Chroma Meter CR-5, Tokyo, Japan) to determine the CIELab coordinates (L^* , a^* , b^*). According to CIE (1986), L^* value indicates lightness (100: white, 0: black), a^* value indicates red–green colour (+: red, -: green) and b^* value indicates yellow–blue colour (+: yellow, -: blue). For more appropriate colour determination, chroma (C^*) and hue angle (h°) were also calculated from a^* and b^* values using the following equations as described by McGuire (1992).

$$C^* = \sqrt{a^{*2} + b^{*2}}$$

$$h^\circ = \tan^{-1} \left(\frac{b^*}{a^*} \right)$$

Emulsion stability

Emulsion stability of sesame paste products was determined, using the oil separation test, as described by Elleuch et al. (2014), with slight modifications. Samples (10 g) were transferred to centrifuge tubes (50 ml), heated to 55 °C in a water bath for 15 min and then centrifuged at 5000 rpm for 15 min. The separated oil was removed with a Pasteur pipette and the tube was weighed. The emulsion stability was expressed as the percentage of oil released from the total oil present in the product.

Texture

The viscosity of carob molasses and sesame paste was measured at 25 °C with a viscosimeter (HA, Brookfield, USA), equipped with spindle 5, at shear rate of 100 rpm. The hardness of the developed blend was also analyzed using a texture analyzer (LLOYD Instruments, England), equipped with an acrylic cylindrical probe (diameter 12 mm), which compressed the sample to 50% of its original height (30 mm) at a rate of 30 mm/min. The texture analyzer was connected to a computer and data analyses were conducted using the software NEXYGEN™ MT

Fig. 3 Different prepared formulations of sesame paste/carob molasses blends

Ratio °Brix	30 %	40 %	50 %
60 °B
70 °B
80 °B

(version 4.5). The hardness (N) was calculated as the peak force of first compression cycle.

Chemical analyses

Global composition

Global composition (moisture, protein, fat and ash) was carried out according to the AOAC methods (AOAC 2000). Moisture was determined by oven drying at 105 °C to a constant weight, in accordance with the Method 934.01. Protein content ($N \times 6.25$) was measured according to the Kjeldahl Method 968.06. Fat content was assessed as described by the Soxhlet Method 989.05, using hexane as extraction solvent. Ash content was quantified by incineration at 550 °C, following the Method 923.03.

Soluble sugar

For sugar extraction, 5 g of samples were homogenized with 20 ml of distilled water and then centrifuged at 6000 rpm for 30 min at room temperature (Biner et al. 2007). The supernatant was filtered through Whatman no. 1

filter paper and the filtrate was used for the determination of sugar content by the phenol–sulfuric acid method (Dubois et al. 1956), using glucose solution as a standard (100 mg/l). Briefly, 200 µl of diluted filtrate were mixed with 200 µl of phenolic solution (5%) and 1 ml of concentrated sulfuric acid (H_2SO_4). The mixture was allowed to stand for 30 min and the absorbance was then measured at 490 nm.

Polyphenols

Polyphenols content was analyzed, according to the Folin–Ciocalteu method, slightly modified (Singleton and Rossi 1965). Beforehand, extracts were prepared as follows: 1 g of each sample was mixed with 40 ml of 50% acetone, homogenized for 30 min and filtered through Whatman no. 1 filter paper (Haddarah et al. 2013). An aliquot of diluted extract (500 µl) was mixed with 2.5 ml of Folin reagent (ten-fold diluted) and 2 ml of saturated sodium carbonate solution (75 g/l). The mixture was placed in the dark for 15 min and the absorbance was measured at 765 nm. A standard curve was prepared with gallic acid solutions,

ranging from 0 to 50 mg/l. Results are expressed as gallic acid equivalent (GAE).

Statistical analyses

Results are expressed as mean of three replications $\pm$ standard deviation. One-way analysis of variance (ANOVA) was conducted, followed by Duncan's multiple range test to compare treatment means. Differences were considered to be significant at $P < 0.05$. Statistical analyses were done with SPSS software (Statistical Package for Social Science, version 20.0).

Results and discussion

Product acceptability

Among the nine prepared blends, only four samples were found to be acceptable, as judged by a preliminary sensory panel from the industry. This analysis was carried out to exclude blends that have oil migrating to the surface (blends made of 30, 40 and 50% molasses at 80°Brix and blends made of 30% molasses at 60, 70 and 80°Brix) as presented in Fig. 3.

The four pre-selected samples (blends made of 40 and 50% molasses at 60 and 70°Brix) (Fig. 3) were re-evaluated for product acceptability, to select only one blend to be analyzed further with carob molasses and sesame paste, in terms of physical and nutritional quality.

The acceptability analysis of the four blends was performed by industrial panelists familiar with sesame-based products. Table 1 presents the acceptability scores for appearance, colour, odour, taste, texture, spreadability and overall acceptability of the prepared blends.

The statistical analysis revealed that the blends prepared with 50% of carob molasses had the highest scores for all

the evaluated attributes, in comparison with the samples containing 40% of carob molasses. For this proportion, the sample made of 60°Brix molasses gained the best score for the overall acceptability ($P < 0.05$) and thus was further characterized in terms of its physical and nutritional properties to study the effect of adding carob molasses on the quality of sesame paste.

Effect of adding carob molasses on the sesame paste quality

Results of physical and nutritional analyses of the selected blend (made with 50% sesame paste and 50% carob molasses at 60°Brix) and its ingredients are presented in Tables 2 and 3, respectively. The statistical analysis showed that carob molasses addition significantly ($P < 0.05$) affected the sesame paste quality.

Effect on physical quality

Table 2 illustrates the main physical properties (emulsion stability, colour and texture) of the carob molasses, sesame paste and the selected blend.

Many food products exist in the form of an emulsion, i.e. oil-in-water or water-in-oil type. Tahin/molasses blend is considered as a typical example of an oil-in-water type emulsion, according to Alpaslan and Hayta (2002). The emulsion stability could be evaluated by the oil separation test, which consists of an alteration in food structure using various treatments, such as heating and centrifugation, in order to expose interior lypophilic groups to the aqueous phase and, thus, allow hydrophilic interactions to occur affecting the oil absorption properties of the food (Elleuch et al. 2014). It is clear from Table 2 that the addition of 50% carob molasses (60°Brix) was efficient to prevent oil separation in the sesame paste and, thus, to form a very stable emulsion even under stressful conditions (heating

Table 1 Acceptability scores of carob molasses/sesame paste blends prepared at different °Brix and proportions of molasses

Attribute	40%		50%	
	60°Brix	70°Brix	60°Brix	70°Brix
Appearance	3.00 $\pm$ 0.85b	2.17 $\pm$ 0.84a	3.50 $\pm$ 0.91b,c	3.83 $\pm$ 0.84c
Colour	3.25 $\pm$ 0.75a,b	2.92 $\pm$ 0.90a	3.25 $\pm$ 0.75a,b	3.75 $\pm$ 0.62b
Odour	2.75 $\pm$ 0.45a	2.58 $\pm$ 0.79a	3.08 $\pm$ 0.67a,b	3.42 $\pm$ 1.00b
Taste	3.25 $\pm$ 1.06a,b	2.67 $\pm$ 0.78a	3.42 $\pm$ 0.67b,c	4.00 $\pm$ 0.85c
Texture	2.92 $\pm$ 0.67a	2.33 $\pm$ 0.78a	3.75 $\pm$ 0.87b	4.08 $\pm$ 1.08b
Spreadability	3.25 $\pm$ 0.87b	1.92 $\pm$ 0.67a	4.00 $\pm$ 0.60c	3.42 $\pm$ 1.00b,c
Overall acceptability	2.83 $\pm$ 0.29a	2.52 $\pm$ 0.35a	4.83 $\pm$ 0.52c	4.17 $\pm$ 0.30b

Results are expressed as mean $\pm$ standard deviation ($N = 12$). Values followed by different letters in the same line are statistically different ($P < 0.05$)

Scoring scale: 1: disliked extremely, 2: disliked, 3: acceptable, 4: liked, 5: liked extremely

Table 2 Physical properties of carob molasses, sesame paste and the blend made with 50% carob molasses at 60°Brix

Parameters	Carob molasses	Sesame paste	Blend
Couleur: L*	30.15 ± 0.01a	72.84 ± 0.06b	33.48 ± 1.41a
a*	11.81 ± 0.88a	4.91 ± 0.03b	5.70 ± 0.08b
b*	1.58 ± 0.29a	24.41 ± 0.06c	2.86 ± 0.06b
C*	11.91 ± 0.91b	24.89 ± 0.07c	6.37 ± 0.09a
h°	7.57 ± 0.82a	78.63 ± 0.03c	26.67 ± 0.14b
Emulsion stability (%)	ND	26.32 ± 0.32b	0.00 ± 0.00a
Viscosity (mPa.s)	245.00 ± 5.00a	3500.00 ± 500.00b	ND
Hardness (N)	ND	ND	1.10 ± 0.10

Results are expressed as mean ± standard deviation ($N = 3$). Values followed by different letters in the same line are statistically different ($P < 0.05$)

ND not determined

Table 3 Nutritional composition of carob molasses, sesame paste and the blend made with 50% carob molasses at 60°Brix

Component	Carob molasses	Sesame paste	Blend
Moisture (A)	42.09 ± 0.22c	0.35 ± 0.71a	22.89 ± 0.13b
Soluble sugar (B)	32.93 ± 3.22c	1.17 ± 0.21a	9.34 ± 0.33b
Protein (B)	2.28 ± 0.23a	25.35 ± 0.35c	16.97 ± 0.35b
Fat (B)	0.45 ± 0.05a	64.56 ± 2.91c	12.05 ± 0.23b
Ash (B)	4.96 ± 0.05b	2.67 ± 0.02a	3.17 ± 0.18a
Polyphenols (C)	1768.12 ± 56.93c	82.80 ± 2.78a	501.45 ± 25.79b

Results are expressed as mean ± standard deviation ($N = 3$). Values followed by different letters in the same line are statistically different ($P < 0.05$)

A: g/100 g fresh matter; B: g/100 g dry matter; C: mg GAE/100 g dry matter

and centrifugation). This result could be explained by the emulsifying capacity of carob molasses, being mainly related to either the sugar molecules or Maillard reaction products that contribute to the emulsification process, thus, improving the emulsion stability (Tounsi et al. 2017). The blend stability may also be attributed to sesame lipoproteins acting as an emulsifier at the oil–water interface, according to Arslan et al. (2005). Alpaslan and Hayta (2002) also studied the effect of added grape molasses on oil separation in sesame paste and showed that increasing the amount of molasses from 2 to 6% further improved its emulsion stability. The authors suggested that the addition of grape pekmez inhibits the coalescence of oil droplets into larger droplets, which have a tendency to separate from the blends. Thus, the formation of a stable emulsion may help to enhance the sensory properties, such as the mouthfeel of the food.

It is known that the alterations in the physical state and structure of a food system may alter the product colour. In this respect, the colour indicators (L^* lightness, a^* redness, b^* yellowness, C^* chroma and h° hue) of carob molasses, sesame paste on the formulated product are shown in Table 2. Significant ($P < 0.05$) reductions in the lightness, yellowness, chroma and hue values were observed between the sesame paste and the molasses/paste blend, leading to a

radical colour change. According to IEC (1999), the mixture between the wood-black red carob molasses ($L^* = 29.8$, $a^* = 11.42$, $b^* = 1.99$) and the beige sesame paste ($L^* = 75.29$, $a^* = 5.13$, $b^* = 23.81$) resulted in the formation of an intermediate brown product ($L^* = 36.72$, $a^* = 4.75$, $b^* = 2.21$). The determination of chroma C^* and hue h° was used also to describe the colour change. The chroma value of the sesame paste decreased under the effect of adding molasses and closely followed the b^* value. This result indicates the formation of brown colour, defined as yellow colour with low b^* positive values (Tounsi et al. 2017). The hue value of the sesame paste also decreased from about 79° to 27° under the effect of adding molasses. This result suggests reduction from a more yellow colour (when h° tends to 90°) to a brown colour (when h° tends to 30°) according to McGuire (1992).

Besides colour, the addition of carob molasses has modified the texture of the sesame paste from a fluid material (characterized by viscosity) to a solid material (characterized by hardness), as presented in Table 2. This finding is in agreement with those reported by previous studies (Alpaslan and Hayta 2002; Arslan et al. 2005) conducted on the rheological properties of grape molasses (pekmez)/sesame paste (tahin) blends. The authors stated that increasing pekmez concentration led to an increase in

the tahin viscosity, resulting mainly from sugar molecular movements and interfacial film formation.

Effect on nutritional quality

The average nutritional composition of the selected blend and its ingredients (sesame paste and carob molasses) is given in Table 3.

The industrial sesame paste was found to be rich in lipids (~ 65 g/100 g dry matter) and proteins (~ 25 g/100 g dry matter). A previous study (Abu-jdayil et al. 2002) reported similar quality characteristics for sesame paste (tehineh) containing 57–65% of lipids and 23–27% of proteins.

On the other hand, carob molasses (60°Brix) prepared for the food application was characterized by high contents of moisture ($\sim 42\%$), sugar (~ 33 g/100 g dry matter), ash (~ 5 g/100 g dry matter) and polyphenols (~ 1800 mg GAE/100 g dry matter). Compared to other studies conducted on the characterization of Turkish commercial products (carob pekmez), the literature reported higher values for sugar content (~ 63 – 71% ; Özcan et al. 2007; Sengül et al. 2007; Tetik et al. 2010) and lower contents of moisture (~ 24 – 35% ; Özcan et al. 2007; Sengül et al. 2007; Tetik et al. 2010), ash (~ 1.5 – 2.5% ; Özcan et al. 2007; Sengül et al. 2007; Tetik et al. 2010) and polyphenols (716–1245 mg GAE/100 g dry matter; Tetik et al. 2011). These differences found between the contents could be probably attributed to the chemical composition of carob fruit, or processing conditions of molasses production and even the methods used for compounds assay.

Hence, the addition of carob molasses greatly affected the nutritional composition of the sesame paste and led to the formation of another product with a different nutritive value (Table 3). In fact, the addition of 50% carob molasses (60°Brix) resulted in a significant ($P < 0.05$) increase in the contents of sugars, and polyphenols in sesame paste. A significant ($P < 0.05$) increase was also observed in the moisture of the sesame paste, from 0.35 to about 23%, due to adding molasses, which probably makes the formulated product more vulnerable to microbial spoilage, especially fungi, if it is not stored correctly (El Gerssifi 1997). It was also noted that the contents of sugars and lipids present in the formulated blend (~ 10 and 12 g/100 g dry matter, respectively) seem to be lower than the expected values for a mixture made of 50% sesame paste and 50% carob molasses (~ 16 and 32 g/100 g dry matter, respectively). This result could be explained by the possibility of these two molecules (sugar and fat) to form a very stable emulsion. Indeed, oil droplets of sesame paste are strongly retained by long chains of sugars molasses, hence generating a very compact network (Maskan and Göğüş 2000).

Consequently, the developed blend was found to have a moderate nutritional composition between sesame paste, characterized by high lipid and protein contents, and carob molasses, characterized by high sugar, mineral and phenolic contents.

Conclusion

Blends, from sesame paste and carob molasses, were developed in collaboration with a local industrial confectionary, “Confiserie Triki-le Moulin” (Sfax, Tunisia), to offer a natural spread to the consumer. Variations in °Brix of the molasses and percentage of paste produced different blends. The blend made with 50% carob molasses at 60°Brix had significantly the highest numerical score for overall acceptability and thus differed from all the other samples. The carob molasses addition affected the physical properties of the sesame paste (oil separation, colour and texture) and led to the modification of the nutritional composition of sesame paste (enrichment in soluble sugars and phenolic compounds, against, reduction in protein and oil contents). Accordingly, such characteristics may qualify sesame paste/carob molasses blend as a promising nutritious and healthy food that could be directly consumed or incorporated in many food formulations, such as pastry and biscuit products.

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