Pastry sauce with carob (*Ceratonia siliqua*) powder

Tatiana Capcanari, Aurica Chirsanova, Eugenia Covaliov, Oxana Radu, Rodica Siminiuc

Technical University of Moldova, Chisinau, Republic of Moldova

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Corresponding author:

Tatiana Capcanari
E-mail: tatiana.capcanari@toap.utm.md

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Abstract

Introduction. The present research discusses the carob pastry sauce production without sugar addition and highlighting its functional and physico-chemical properties.

Materials and methods. To evaluate the possibility of carob use in the production of pastry sauce, powder of carob pods and beans was introduced in the recipe of cocoa sweet pastry sauce. The functional and physico-chemical properties of the produced sauce were characterized in terms of rheology, chemical composition, sensory analysis, antioxidant activity, and total phenol content.

Results and discussion. The incorporation of carob morphological parts (beans or pod pulp) in the pastry sauce recipe in order to replace the sugar and cocoa reduced its energy value by 60% compared to the original recipe (with cocoa and sugar). The addition of carob pod powder in the composition of the pastry sauce increased the content of Ca and Fe by 2.9 and 5.1 times, respectively. The biological value of sauce with carob pod powder showed an increase in terms of 1,1-Diphenyl-2-picryl-hydrazyl (DPPH) inhibition antioxidant activity up to 95.97% compared to 60% for control, and total phenol content up to 29.12 mg gallic acid equivalent (GAE) per g compared to 5.11 GAE/g for control.

Addition of carob pod powder in sauce formulations has a positive influence on the rheological properties of the sauces, leading to the increase of their viscosity, as well as their stability to the increase of shear stress and shear rate.

The sensory evaluation of sauces prepared with the addition of carob pod powder or carob bean powder showed that all sauces had a fine and homogeneous consistency, a pleasant flavor and smell characteristics of the added ingredients: the pastry sauce with carob pod powder had a specific smell and flavor of dark chocolate, and the pastry sauce with carob bean powder had a hint of caramel flavor.

Conclusions. The incorporation of carob pod or bean powder in pastry sauces to replace cocoa and sugar, enhanced the quality and biological values of the sauce by increasing its mineral content, antioxidant activity, total phenol content, the consumer acceptance, decreasing at the same time energetical value of the product.

Introduction

Pastries include a vast variety of fat and sugar rich products (Ooms et al., 2016). Due to the high amount of sugar and fat, on one hand, pastries are viewed as a source of products related to happiness (Wahl et al., 2017), and, on the other hand, the consumption of pastry is often associated with an increase in obesity in children and adults (Karp et al., 2016). Often, at serving phase, pastry is associated with sauces in order to reveal the taste of the product. The sauce can complement the delicacy or be a full-fledged companion for it. Basic pastry sauces, represent mixtures of divers ingredients, the most common being sugar, chocolate, caramel, cream, fruits, and berries (Benković et al., 2019). The pastry sauces are widely used by not only catering establishments, but are also available in stores for individual consuming. Thus, pastry sauces have positive effects on the products commercial quality, in terms of flavor, colour and aspect. However, because of their composition, sauces increase the calorific value of the pastry products enrolling them in the category of obesogenic foods (McKerchar et al., 2020). Thus, numerous studies are being carried out in order to obtain new natural additives to food products, including for confectionery sauces, preventing an increase in their calorie content (Chidambaram, 2021; Gorodyska et al., 2018; Kwon et al., 2021; Selvasekaran and Souza et al., 2021; Stabnikova et al., 2021).

Currently, vegetable raw materials are increasingly used in the development of functional foods (Popovici et al., 2019, Covaliov et al., 2021), including sauces: in the manufacture of emulsified sauces (Mirzanajafi-Zanjani et al., 2019), tomato sauces (Ferro et al., 2021), and confectionery sauces (Abushal et al., 2021). They diversify the range of products, making them more attractive to consumers. In some cases, these ingredients increase the energy value of the products, especially when butter, oils, and sugar are included in their recipes, but the biological value of such products remain low (Lebedenko et al., 2021).

Carob (*Ceratonia Siliqua* L., tree of the pea family *Fabaceae*) is a fruit species for the Mediterranean climate attracts attention for its high biological and nutritional value. Carob fruits are rich in natural sugars – 48–56% of dry weight, especially sucrose, fructose and glucose. The syrup obtained from the carob pods is recommended to be used as a sweetener, together with bee honey (Atasoy, 2009; Lambert et al., 2018). Several studies were made in order to show the carob high biological potential (Fidan et al., 2020), its consumption in the form of powders or tinctures were advised due to high content of antioxidants (Ibrahim et al., 2020; Vitali Čepo et al., 2014). In addition, its glycemic index is low, and carob pods do not include caffeine in the composition (Nasar-Abbas et al., 2016; Papakonstantinou et al., 2017; Rodríguez-Solana et al., 2021). More than, it was found that carob having high antioxidant capacity may serve as an effective anti-obesity compound (Fujita et al., 2021) and, so, can be used in the production of food recommended to people suffered from obesity. Meanwhile obesity is a major risk factor for various chronic diseases such as diabetes, cardiovascular disease, and cancer. All of the above indicates that carob fruits can be considered as a functional ingredient can be used as a source of biologically active compounds for the production of functional food for special nutritional requirements (Ivanov et al., 2021).

The aim of the present research was to study physico-chemical and functional characteristics of carob pastry sauce.

Materials and methods

Carob fruit collection and dry powder preparation

Carob pods were harvested in the central region of the Republic of Moldova at the middle of October 2021. During this period they reach a good state of ripeness. Carob beans were carefully separated from the pod pulp. The raw materials were washed thoroughly, followed by a drying procedure in order to remove any moisture acquired during drying during 48 hours at 40°C. The dried carob pods pulp and beans were ground until powder was obtained.

Preparation of carob pastry sauce

For the functional pastry sauce production, a standard chocolate sauce formulation was used. The usual ingredients for the pastry sauce were as: cocoa powder, pasteurized milk (3.5% fat), butter (82.5% fat), powdered sugar, vanilla extract and processed drinking water. Carob (beans and pods) powder was added to produce the functional pastry sauce.

Two types of sauces by addition of two types of carob powder produced from different morphological parts of carob, namely, carob beans and carob pods pulp, were prepared. Technology includes the use of moderate heat treatment. During the technological process, it was found that carob powder serves as a thicker that is why in the carob pastry sauce formulation sugar was replaced with water.

Firstly, the mixture of pasteurized milk with vanilla essence was the prepared. The butter was melted at a temperature of 30 °C and put into prepared mixture. Then, the rest of the ingredients followed by powdered sugar (or water) and carob pods pulp or carob beans powder was added. A short (5 min) heat treatment at a temperature up to 80 °C under continuous mixing to obtain a homogeneous mass to prepare the sauce was done, and the mass was cooled to 20 °C.

Determination of protein, carbohydrates and lipids content

The standard methods adopted by the AOAC (Association of Official Analytical Chemists) were used to determine the protein (2001.11), carbohydrates (2020.07), and lipids (996.01) contents (Horwitz, 2007; McCleary and McLoughlin, 2021).

Determination of mineral content

Mineral content was determined by Atomic Absorption Spectrometry (AAS) official method. The content of Ca, Fe and K in the experimental samples was determined according to García and Báez (2012).

Determination of total polyphenol content (TPC)

Total polyphenol content was determined by Folin-Ciocalteu method described by *Lamuela-Raventós* (Lamuela-Raventós, 2017).

Determination of antioxidant activity (AA)

Antioxidant activity was measured using 1,1-Diphenyl-2-picryl-hydrazyl (DPPH) method (Nenadis and Tsimidou, 2017).

Rheological measurements

The rheological measurements were performed by using a DV-III Ultra Rheometer (Brookfield Inc., USA) at 25±0.01 °C equipped with Peltier Temperature Controller Unit. The measuring system consisted of a cone and plate sensor with a diameter of 2 cm and cone angle of 2°. Shear rate range was 0–300 s^{-1} within 600 s. For each measurement, 1 ml of sample was poured over the plateau of rheometer. Each measurement was done in triplicate. Rheological parameters (shear stress, shear rate, apparent viscosity) were obtained from the Bohlin CVOR 150 data analysis software (Lystopad et al., 2020).

Sensory test of carob pastry sauces

Sensory test was performed by method described by Rachel Byarugaba and ISO 6658:2017 (Byarugaba et al., 2020). The study of sensory properties of carob pastry sauces the scoring scale from 1 to 5 in two groups of developers was used. 5 basic parameters according to ISO 6658:2017 were assessed. The resulting score for each quality index was appreciated by tasters and entered in the individual sensory analysis sheet. Following the statistical processing of the grades, the quality of the experimental samples was assessed.

Statistical analysis

All experiments were carried out in triplicate. The results are given as mean±standard deviation (SD). Statistical analysis was performed using XLstat (2020 version) software.

Results and discussion

Preparation of carob pastry sauces

During the research, seven samples of sauces were prepared. All recipes contain pasteurized milk, 30 mL; butter, 15 g; vanilla essence, 0.1 mL. The difference in recipes was in the content of cocoa, carob pod powder, carob bean powder, and powdered sugar (Table 1).

Table 1

Functional carob pastry sauces formulations

N of sauce	Cocoa, g	Carob pod powder, g	Carob bean powder, g	Powdered sugar, g	Water, mL
1 (control)	10	-	-	45	-
2	-	10	-	45	-
3	-	-	10	45	-
4	-	5	5	45	-
5	-	15	-		40
6	-	-	15		40
7	-	7.5	7.5		40

Sauce 1 was used as control with 10% of cocoa. Sauces 2, 3 and 4 contained 45 g of powdered sugar and 10% of carob pod powder; 10% of carob bean powder; mixture of 5% carob pod powder and 5% carob bean powder, respectively.

After the primary sensory testing of the sauces 2, 3, and 4, it was found that these sauces were very viscous and the taste was extremely sweet. The consistency of these sauces was almost solid, probably due to the high pectin content in carob. That why the sauces 2, 3, and 4 were excluded from the future research. The sauces 5, 6, and 7 were prepared with replacement of 45 g sugar with 40 mL of water. Sauce 5 with carob pod powder had a more intense bitter taste specific to dark chocolate, while sauce 6 with carob bean powder had a sweet aroma and flavor specific to caramel. Sauce 7 contains a mixture of carob pod powder, 7.5%, and carob bean powder, 7.5%. The consistency of sauces 5, 6, and 7 was more appropriate to control, the traditional pastry sauces consistency. The obtained sauces were placed to sterilized glass vessels, sealed and refrigerated at 4-6 °C for 24 hours before being use for analysis.

Physico-chemical characteristics of carob pastry sauces

Physico-chemical characteristics of studied sauces are shown in Table 2.

Table 2

Physico-chemical characteristics of carob pastry sauces

Components	**Sauces**			
	1 (control)	**5**	**6**	**7**
Protein, g/100 g	3.60±0.06	2.90±0.02	3.10±0.04	3.00±0.02
Carbohydrates, g/100 g	22.10±0.23	6.90±0.17	7.20±0.24	7.05±0.11
Lipids, g/100g	14.40±0.21	5.10±0.09	5.30±0.12	5.20±0.15
Energy value, kcal	230.70±1.32	85.10±0.45	88.90±0.76	87.00±0.54
Ca, mg/100 g	69.60±0.72	159.60±0.98	155.50±1.21	157.50±1.32
Fe, mg/100 g	0.13±0.01	1.17±0.02	0.91±0.02	1.04±0.01
K, mg/100 g	110.00±1.03	171.75±1.15	162.40±1.13	167.07±1.43

According to the results all sauces with carob powder had a significantly increasing content of mineral components, namely calcium (Ca), iron (Fe), and potassium (K) in comparison with traditional sauce (control 1) prepared with cocoa and powdered sugar. In the sauce with carob powder the calcium content increased more than 2 times, iron up to 9 times, and potassium up to 1.5 times. The content of protein almost did not change, meanwhile the content of carbohydrates and lipids significantly decreased. One of the most important characteristics of the carob pastry sauces is the energy value, which was reduced from 230.7 kcal to 88.9–85.1 kcal that is 2.7 times less than energy value of control (sauce with cocoa and sugar). The obtained data demonstrate the increased biological value of the experimental samples, but a lower energy value, which allows the recommendation of these products as a functional sauce.

Following the research of the functional potential of carob, it has been found that it is an important source of polyphenols, which show a strong antioxidant activity (Rtibi et al., 2015; Stavrou et al., 2018). In the present research, the total content of polyphenols was determined, as well as the antiradical activity of DPPH and in experimental sauces, in order to establish the effect of incorporating carob in the elaborated products (Table 3).

Table 3

Total polyphenol content and antioxidant activity of carob pastry sauces

Sauces	Total polyphenol content mg GAE/ g	DPPH, %
1 (control)	5.11±0.12	60.04±0.26
5	29.12±0.24	95.97±1.08
6	22.15±0.11	88.08±0.98
7	26.09±0.08	93.75±1.05

A positive correlation between antioxidant activity and total phenols content was found for studied sauces. Sauce 5 prepared with carob pod powder has a higher content of polyphenols than sauce 6 with carob bean powder contributing to a higher antioxidant activity of sauces 5. The highest total phenol content, 29.12 mg GAE/g, was determined for the sauce 5 also. According to Turhan et al. (2006), the total polyphenol content of carob pods is 17.50 mg/g. On the other hand, in their research, Mahtout et al. (2016) states that the total phenol content in carob pods reaches the value of 10.53 mg/g, while in beans this content is 17.23 mg/g (Mahtout et al., 2016). According to Cavallaro et al. (2021), the difference in the phenol amounts can be explained by the genotype, originating region, soil type, amount of precipitation (Cavallaro et al., 2021). The lowest total polyphenol content and antioxidant activity was in control, prepared with cocoa powder, 5.11 mg GAE/g and 60%, respectively, although according to Urban Urbańska and Kowalska (2019) the total content of polyphenols in fresh cocoa beans varies between 50–60 mg/g and can decrease up to 9.96–37.81 mg/g depending on the origin of the beans and the roasting treatment parameters.

Rheological properties of carob pastry sauces

The study of the rheological characteristics of foods allows to give characteristic basic quality indicators according to the values of structural and mechanical characteristics (Gonzalez-Gutierrez and Scanlon, 2018). Determining the structural and mechanical indicators of confectionery sauces, such as viscosity, allows obtaining data to improve properties: structure, texture, and shape. In order to investigate the rheological stability of the investigated sauces, the samples were subjected to research to increase shear stress and shear rate. For functional confectionery sauces, the rheological properties are determined by the value of the actual viscosity. Analyzing the rheograms for initial samples and after 4 months of storage, it was found that when increasing shear stress and shear rate, the viscosity of the emulsions decreases significantly, which can be explained by destroying their structure (Figure 1).

Comparing with control the sauces with carob powder were more stable and withstood a shear rate up to 4000–5200 s^{-1}. It was observed that the actual viscosity is directly dependent on the nature and composition of the studied pastry sauces. When the carob bean and pod powder is incorporated in sauce, the effective viscosity increases. For the control sauce 1 the value of this index changed from 11.0 to 10.7 Pa·s; for the sauce with carob bean powder from 16.5 to 16.0 Pa·s; for the sauce 6 with the bean powder from 18.1 to 17.6 Pa·s for fresh samples and after 4 months of storage, respectively.

After 4 months of storage, a non-essential change of the effective viscosity was observed, which proved the stability of the carob pastry sauces. The results of the investigations regarding the rheological properties of the sauces allowed us to state that the carob powders have a positive influence, lead to the increase of the viscosity of the sauces, as well as their stability to the increase of shear stress and the shear rate.

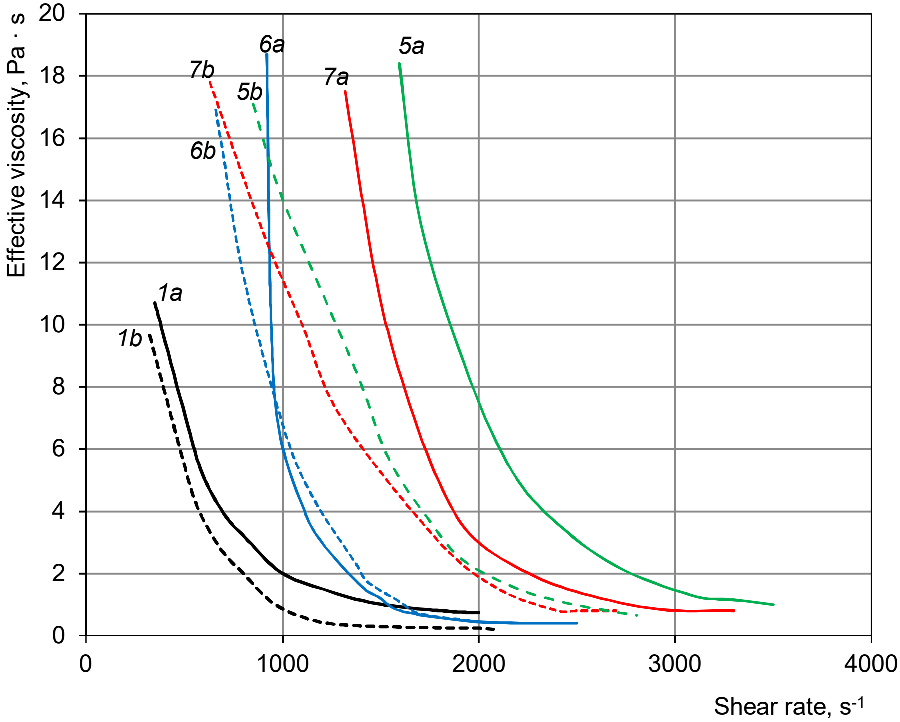

Figure 1. Variation of the effective viscosity according to the tangential stress of the carob pastry sauces:

1a – sauce 1 (control); 1b – sauce 1 (control) after 4 months of storage
5a – sauce 5; 5b – sauce 5 after 4 months of storage
6a – sauce 6; 6b – sauce 6 after 4 months of storage
7a – sauce 7; 7b – sauce 7 after 4 months of storage

Sensory test of carob pastry sauces

The evaluation of the sensory properties of carob pastry sauces was done using the scoring scale from 1 to 5 in two groups of developers. The results of the evaluation of sensory properties of the functional confectionery sauces are presented in Table 4.

Table 4

Sensory indices of the carob pastry sauces

Sensory properties	1 (control)	5	6	7
Flavor	4.25±0.03	4.46±0.02	4.78±0.03	4.54±0.01
Aroma	4.21±0.05	4.67±0.02	4.86±0.05	4.59±0.02
Color	4.32±0.01	4.43±0.01	4.79±0.03	4.45±0.04
Aspect	4.78±0.05	4.58±0.01	4.69±0.04	4.54±0.05
Consistency	4.56±0.03	4.45±0.03	4.87±0.01	4.62±0.03
Average score	4.42±0.03	4.52±0.02	4.80±0.03	4.55±0.03

The photos of sauces were shown in Figure 2.

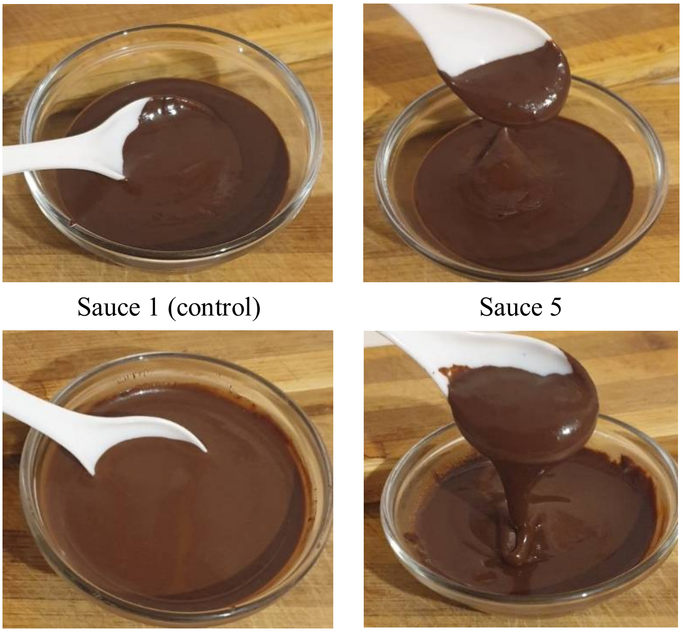

Figure 2. Images of experimental functional sauces

After evaluation of the sensory properties, it was found that all the sauces had a pleasant flavor and smell, and they had a characteristic consistency for each individual confectionery sauce. Based on the sensory evaluation, the sauce 6 with carob bean powder had better appearance and good consistency, as well as in a more expressive, a fine and pleasant flavor of caramel, obtaining an average appreciation score of 4.80. The sauce 5 with carob pod powder had a pronounced dark chocolate flavor and was highly appreciated by tasters with an average score of 4.52. It should be mentioned that the sauce made from a mixture of carob pod and bean powder was evaluated as one of high quality, obtaining an average score of 4.55. Taking into account the average scores, all carob pastry sauces were considered as acceptable.

Conclusion

- The addition of carob pod or bean powder in pastry sauces is a good way to reduce the amount of sugar in the product. The substitution of cocoa powder and sugar with carob pod or bean powder reduces the caloric value of pastry sauces more than 60 % of initial value.
- Including carob pod or bean powder in pastry sauces increased their biological value, particularly, of total phenol and calcium, iron, potassium contents, and antioxidant activity, being in the same time an alternative for the consumers of decaffeinated products.

– The addition of carob pod or bean powder in pastry sauces has a positive influence on their rheological properties increasing the viscosity of the sauces, as well as their stability during storage.

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