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Optimization of the basic formulation of traditional molasses cream using D-optimal mixture design based on textural characteristics

Ş Çelik, N Ünver* & D Kazan
Food Engineering Department, Engineering Faculty, Harran University, Sanliurfa 63300, Turkey
*E-mail: on.unver@gmail.com

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Molasses cream, which is a blend of Sanliurfa butterfat and grape molasses, is one of the traditional food products of South-eastern Anatolia. Since emulsion is not formed in traditional molasses cream, phase separation occurs over time. The molasses cream formulation was modified with the addition of soy lecithin as an emulsifying agent to prevent phase separation in this study. D-optimal mixture design was used to optimize the basic formulation of the molasses cream according to textural analysis. As a result, the best mixture was the formulation that contained 29.76% anhydrous butterfat, 67.74% molasses and 2.50% lecithin with desirability equal to 0.947. The optimized molasses cream, which had a slightly bright and brownish colour approved by the panellists, gained a high score (>7.0) in terms of odour, flavour, mouthfeel, appearance and overall acceptability. The low free fatty acidity, peroxide and TBARs value indicated that the heating and mixing treatments did not cause significant oxidation in the oil phase.

Keywords: Anhydrous butterfat, D-optimal mixture design, Grape molasses, Molasses cream, Textural analysis

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Molasses cream is a blend of Sanliurfa butterfat (a kind of anhydrous butterfat) and grape molasses, and it is one of the traditional foods of South-eastern Anatolia[1]. Traditional molasses cream known as ‘Runı Sor’ in the region, a blend of butterfat and grape molasses, is produced in September. These two components are blended and filled into a leather bag, and then stored for 2-3 months in a relatively cool, dark and moisture-free environment. The composition of the traditional product consists of approximately 25-35% butterfat and 65-75% grape molasses. The cream is heated, mixed, and consumed at breakfast on cold winter days. Due to its high fat and sugar content, the cream is a product with high-energy value. It also contains a significant amount of various vitamins (A, E, B_1 and B_2), mineral substances (Ca, Fe, P, K, Mg and Cr) and phenolic compounds[2]. In addition, the molasses cream is expected to have a long shelf life because the phenolic compounds in molasses inhibit / retard the oxidative degradation of anhydrous butter.

Textural properties of food emulsions, which is an important feature for consumer choice, research and development activities, can be determined by sensory and instrumental analysis. Sensory analysis is defined as the identification, scientific measurement, analysis and interpretation of the senses for food perceived by seeing, smelling, tasting, touching and hearing. This method, which is based on individual evaluations, can be difficult to understand and evaluate if the panellists are not well-trained. On the other hand, instrumental analysis is based on imitating human senses such as biting, chewing and flow behaviour of foods in the mouth with a mechanical texture device or instrument. Instrumental measurement methods that can be carried out quickly and easily have increasingly been used in the food industry. For the optimization of food emulsion in terms of formulation, the instrumental analysis is stronger and more reproducible than the sensory analysis for the reasons mentioned above. Mixture Design is one of the useful tools for the optimization of food formulation. The design holds the number of trials at the minimum and provides a multiple regression approach. According to this design, the proportions and levels of the components in the mixture are interdependent, and the sum of all components is always one or 100%[3].

Although the amounts of ingredient and some physicochemical parameters of the product had been recommended in our earlier study[1], no scientific study related to the optimization of the basic formulation of

*Corresponding author

the molasses cream has been previously reported. Therefore, the objective of the study is to optimize the basic formulation of the traditional molasses cream using a D-optimal mixture design with respect to instrumental textural properties and determine some physicochemical and sensory characteristics of the optimized product.

Materials and Methods

Material

Grape molasses was obtained from retailers in Sanliurfa, Turkey. Sanliurfa butterfat was obtained from small-sized dairy plants in the Karacadağ region of Sanliurfa, Turkey. In this study, soy lecithin (E322) was chosen (Alfasol, Kimbiyotek Chem. Co., İstanbul) as an emulsifying agent because its yellow-brownish colour is appropriate for the molasses cream.

Methods

Production of the traditional molasses cream

Traditional molasses cream was produced following the procedure described by Celem and Celik[1], with some modifications. The required amount of anhydrous butterfat was melted in the jug of the mixer robot (High shear mixers, Ultrablend Cook - BL962, Tefal UK Ltd., Slough, Berkshire, UK) at 60°C for 3 min. After adding the required amount of soy lecithin, the mixture was stirred for 30 sec at the third level of the blending speed of the mixer robot. Then, the required amount of grape molasses was added to the jug of the mixer and mixed at the third level, and then the mixture was heated at 80°C for 15 min. Finally, the mixture was stirred at the third level of the blending speed for 3 min. The obtained molasses cream was hot-filled into the glass jars (200 mL), and lids were closed. Then the filled glass jars were immediately immersed into a cool water bath (20°C) and then stored at 4°C.

Experimental design for optimization of formulation

D-optimal mixture design (Design Expert Software 8.0.7.1, State-Ease Inc., Minneapolis, USA), which focuses on estimating the best possible model coefficients, especially for constrained mixture regions, was used to investigate the effects of ingredients on the textural attributes of the product. The level range of the ingredients, determined by using preliminary trials, are presented in Table 1. This design was a quadratic design with five replicates. The arrangement of the D-optimal mixture design was shown in Table 2.

Table 1 — Experimental levels of independent variables for the D-optimal mixture design

Independent variables	Units	Symbol	Levels	
			Low	High
Sanliurfa butterfat	%	X_1	10	30
Grape molasses	%	X_2	68.5	89.5
Soy lecithin	%	X_3	0.5	2.5

Table 2 — D-optimal mixture design arrangement and experimental result for the response variables of the molasses cream

Trial no	Variable levels			Mean value of response variables			
	X_1 (%)	X_2 (%)	X_3 (%)	Hardness (g)	Consistency (g.sec)	Cohesiveness (g)	Work of cohesion (g.sec)
1	24.967	74.533	0.500	23.6333	65.4667	-37.6933	-34.65
2	10.000	89.500	0.500	16.15	48.205	-21.68	-48.245
3	26.528	70.972	2.500	96.7633	248.537	-198.32	-150.82
4	21.551	75.952	2.497	71.91	196.652	-160.162	-136.632
5	30.000	68.616	1.384	77.68	212.9	-175.003	-136.557
6	19.027	79.315	1.658	48.815	135.8	-121.985	-76.335
7	10.556	86.944	2.500	36.2267	107.143	2.9467	-64.5267
8	10.556	86.944	2.500	28.505	86.11	-74.715	-58.535
9	19.027	79.315	1.658	65.805	177.56	-165.46	-106.28
10	29.760	67.740	2.500	81.185	197.305	-184.525	-158.77
11	24.967	74.533	0.500	33.61	99.755	-80.77	-78.22
12	13.548	85.952	0.500	22.21	66.0933	-37.77	-29.2133
13	30.000	68.616	1.384	58.62	143.34	-138.32	-115.44
14	17.329	82.171	0.500	23.105	66.57	-44.425	-32.01
15	10.000	89.500	0.500	18.9267	59.06	-21.8567	-59.1067
16	14.648	82.935	2.417	38.54	117.22	-83.505	-74.795

Texture measurement

Texture measurement was carried out using a TA-XT2 Texture Analyser (Stable Micro System Ltd., UK) based on the back extrusion method at 4±2°C according to the method suggested by Liu et al.[4]with a slight modification. For the measurement, a disc probe (Diameter: 30 mm, TA-30A) using a 50 kg load cell attached to the instrument was compressed to 30 mm depth of the sample with a test speed of 1 mm/s. Pre-test speed and post-test speed were set at 10 mm/s, and the trigger force was 10 g. The force-time curves were analysed for hardness (g), consistency (g. sec), cohesiveness (g), work of cohesion (g. sec). Tests were carried out in standard size glass jars (50 mm diameter). When the surface trigger of 10 g was attained (*i.e.*, the point at which the disc's lower surface is in full contact with the product) the molasses cream was subjected to compressive force by probe up to the distance of 30 mm, afterwards the probe returns to its original position.

Optimization and statistical analysis

Analysis of variance (ANOVA) was used to evaluate the main and interaction effects of the variables on textural attributes[5]. The linear, quadratic, and cubic models were presented in Equations I, II and III, respectively.

$$Y = \lambda_1 X_1 + \lambda_2 X_2 + \lambda_3 X_3 \qquad \ldots(1)$$

$$Y = \lambda_1 X_1 + \lambda_2 X_2 + \lambda_3 X_3 + \lambda_1 \lambda_2 X_1 X_2 + \lambda_1 \lambda_3 X_1 X_3 + \lambda_2 \lambda_3 X_2 X_3 \qquad \ldots(2)$$

$$Y = \lambda_1 X_1 + \lambda_2 X_2 + \lambda_3 X_3 + \lambda_1 \lambda_2 X_1 X_2 + \lambda_1 \lambda_3 X_1 X_3 + \lambda_2 \lambda_3 X_2 X_3 + \lambda_1 \lambda_2 \lambda_3 X_1 X_2 X_3 \qquad \ldots(3)$$

In these equations, Y represents the estimated response, λ is the constant coefficients for linear and non-linear terms, and X represents the coded independent variables. The goodness of model fit was determined by lack of fit statistics and coefficient of determination (R^2). The numerical optimization was used to find the optimum proportion of anhydrous butterfat, grape molasses, and soy lecithin. The proportions of the ingredients were kept within the range, whereas the responses were either maximized or minimized. In order to obtain a consistent and spreadable cream, the hardness and consistency were maximized, while the cohesiveness and work of cohesion were minimized.

Sensory analysis

The molasses cream was produced according to the optimized formula with the highest desirability level. Eight trained panellists in the Food Engineering Department of Harran University evaluated the molasses cream according to the 9-point hedonic scale (1 = dislike extremely, 5 = neither like nor dislike, and 9 = like extremely)[6]. All of the panellists were nonsmokers and familiar with the molasses cream. The ages of the panellists ranged from 25 to 50 and, four of them were females. The molasses cream was served with sliced bread. Panellists were asked to evaluate the sample in terms of odour, texture, flavour, mouth feel, appearance and overall acceptability.

Physicochemical characteristics of the optimized molasses cream

The colour was measured using a Hunter lab Colour Quest Instrument (Hunter Associates Laboratory, Inc., Reston, VA 22090, USA). pH value was determined using a laboratory pH meter (Model HQ40d, Hach Company) at a temperature of 20±0.5°C[7]. The water activity was determined using an AquaLab® dew point water activity meter (model 4TE, Decagon Devices Inc., Pullman, WA, USA) at 20°C. Viscosity measurement was carried out using a Brookfield viscometer (model DV-II + Pro, Brookfield Engineering Laboratories, Middleboro, MA, USA) at 20°C with a spindle (S6) rotation of 10 rpm.

For the determination of Hydroxymethylfurfural (HMF)[8], free fatty acidity[9], peroxide value[10] and Thiobarbituric acid reactive substances (TBARs) value[9], the molasses cream was filled into 50 mL centrifuge tubes, and then the tubes were frozen at -24°C for 24 h. Then the samples were thawed at 25°C for 1 h, and the tubes were centrifuged at 4000 rpm for 10 min at room temperature. Then the oil phase (upper phase) and the molasses phase were separated for the analysis.

Result and Discussion

ANOVA results according to the effect of model and independent variables on the response variables were presented in Table 3. The results were used to check the adequacy of predicted models and determine the significant variables. Each model was assessed as a function of linear and interaction terms. The quadratic vs. linear model ($p<0.001$) was found convenient to explain the variability in the hardness, cohesiveness and work of cohesion, while the linear vs. mean model ($p<0.001$) was found convenient to explain the variability in the consistency. The

Table 3 — ANOVA results according to the effect of model and independent variables on the response variables

Source	DF	Hardness		Cohesiveness		Consistency		Work of Cohesion	
		SS	F-value	SS	F-value	SS	F-value	SS	F-value
Model	5	9090.43	23.25***	58077.81	25.13***	46888.90	23.75***	25495.22	18.19***
Linear mixture	2	7992.82	51.11***	48654.05	52.63***	46888.90	23.75***	21873.90	39.01***
AB	1	60.41	0.77	1416.40	3.06	-	-	168.90	0.60
AC	1	338.40	4.33	4915.12	10.63*	-	-	562.64	2.01
BC	1	273.78	3.50	4311.46	9.33*	-	-	424.96	1.52
Residual	10	781.99		4622.62		12831.34		2803.81	
Lack of Fit	5	372.58	0.91ns	679.95	0.17ns	8672.14	1.30ns	1106.39	0.65ns
Pure Error	5	409.41		3942.68		4159.21		1697.42	
Cor Total	15	9872.41		62700.44		59720.24		28299.02	

***: Significant difference with p<0.001, **: Significant difference with p<0.01, *: Significant difference with p<0.05, ns: not significant, DF: Degree of freedom, SS: Sum of squares.

Table 4 — Regression coefficients and coefficient of determination for the adjusted model to experimental data in D-optimal mixtures design for textural parameters

Variables	Estimated coefficients						Coefficient of determination (R^2)		
	X_1	X_2	X_3	X_1X_2	X_1X_3	X_2X_3	R^2	Adj. R^2	Pred. R^2
Firmness (g)	26.78	16.77	-4631.79	23.91	5918.00	5250.31	0.92	0.88	0.77
Consistency (g.sec)	149.30	36.67	944.88	-	-	-	0.79	0.75	0.67
Cohesiveness (g)	-38.86	-19.50	18711.54	-115.76	-22554.17	-20835.16	0.93	0.89	0.76
Work of Cohesion (g.sec)	-68.77	-44.87	5725.42	39.97	-7630.92	-6541.19	0.90	0.85	0.73

Adj: Adjusted, Pred: Predicted

predicted models, the significance of the regression coefficients and the R^2 values were presented in Table 4. The R^2 values for hardness, cohesiveness and work of cohesion were close to 1.00, indicating that the fitted-quadratic models were accounted for more than 90% of the variance in the experimental data, which were found to be highly significant. On the other hand, the R^2 values of consistency were found lower than the other textural parameters (78.51%). The R^2, adjusted R^2 and predicted R^2 were found very close to each other, indicating that a good agreement between the predicted and the actual values for the textural parameters occurred. Kwaw *et al.*[11] studied the effects of the components on the baking time, cookie width, diameter, hardness and sensory attributes of Parkia biglobosa flour-based cookie using D-optimal design. Similarly, the researchers reported that the R^2 values of the linear mixture model were found higher than 0.76. The researchers indicated that the slightly lower adjusted R^2 values compared to the R^2 values might be sourced from the size of the trial generated by the software. Sethi and Balasubramanyam[12] employed a central composite design to optimize the level of ingredients of butter fruit incorporated fat spread using instrumental textural analysis. They reported that quadratic models for firmness, work of shear and stickiness were found adequate to explain the variability in the textural characteristics with a high coefficient of determination (R^2>0.90).

Effect of proportions of the components on the firmness of molasses cream

Firmness, also known as hardness, is the maximum force or peak of the force-time curve. It can be defined as the force required to penetrate a substance with molar teeth in terms of sensory perspective[13-15]. As shown in Tables 3 and 4, the coefficient of determination (R^2) was 0.92, and the lack of fit was not significant (F-value = 0.91) indicating that the quadratic model was sufficient for evaluating the hardness value of molasses cream. The final equation of hardness in terms of L-pseudo-components could be obtained using the estimated coefficients in Table 4.

The effect of the proportion of each component on the firmness was shown in the trace (Cox) plot (Fig. 1a). As shown in the trace plot, the proportions of all the components affected the firmness value of molasses cream. Increasing proportions of both anhydrous butterfat and lecithin caused an increase in firmness, whereas the increase in the proportion of

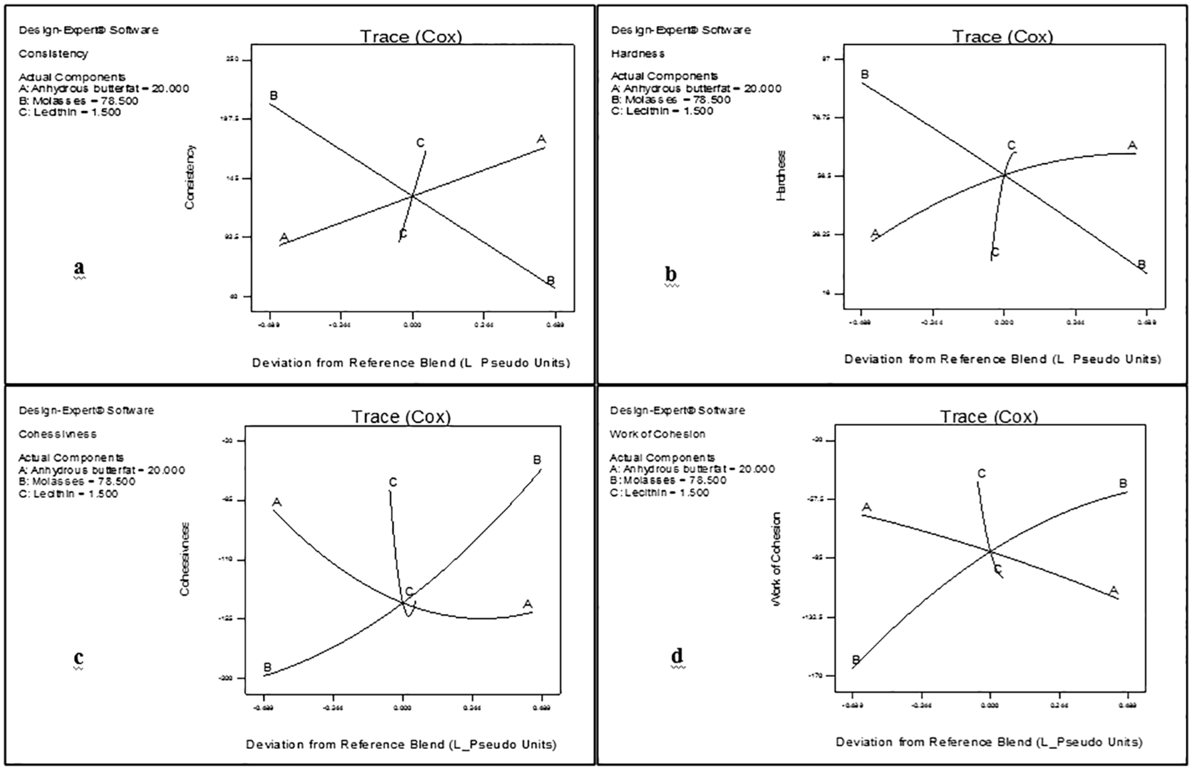

Fig. 1 — Cox trace plots for firmness (a), consistency (b), cohesiveness (c) and work of cohesion (d) of molasses cream

molasses caused a decrease in the firmness of the cream. The anhydrous butterfat was solid because of the saturated fatty acids in the structure, while the molasses was semi-solid or fluid at 4°C. Stabilizing effect of lecithin increases the viscosity of the cream through a stable fat crystal network, which held solid particles in suspension. Thus, the increase in the proportion of lecithin positively affects the firmness of the cream. It is stated that the firmness of emulsions increased with the increase of oil and stabilizer concentration[16-18]. On the other hand, Zahedi and Mazaheri-Tehrani[19], investigated the optimum formula of spreadable halva fortified with soy flour with a user-defined mixture design, reported that the hardness value of halva mixtures was not affected by the emulsifier amount.

Effect of proportions of the components on the consistency of molasses cream

Consistency (g. sec), which is an empirical measurement of the flow of a liquid or semi-solid sample for a given time at a given temperature, is defined as the area of the positive region of the force-time curve in the back extrusion method[20]. As the area value increases, the sample is expected to become thicker[21]. Consistency is an important textural parameter for the eating quality and acceptability of semi-solid food[22]. F value of the linear model and insignificant lack of fit implied that the model was sufficient to evaluate the consistency values according to the ANOVA results presented in Table 3. In other words, the interactions of the components were not significant for consistency. This can be due to the entrapped air gaps that occur in filling the cream into the jars. The air gaps could cause the distribution of compression force non-uniformly on the surface of the cream, where the back-extrusion probe contact. The regression model of the consistency could be obtained using the estimated coefficients in Table 4 in terms of L-pseudo-components.

As shown in Figure 1b, the proportions of all components in the molasses cream affected consistency linearly. Similar to hardness, consistency increases in direct proportion to the anhydrous butterfat and lecithin, while inverse proportion to the molasses.

Effect of proportions of the components on the cohesiveness of molasses cream

Cohesiveness (g) is the maximum negative force of the force-time curve obtained during the return of the probe. Sensory evaluation of the cohesiveness is difficult due to the relative insensitivity of teeth[14,15]. Based on the ANOVA results presented in Table 3, the lack of fit value of cohesiveness was not significant, which implies that the quadratic model is appropriate. The regression model of cohesiveness could be obtained using the estimated coefficients in Table 4 in terms of L-pseudo-components.

The multiple regression model for predicting cohesiveness could explain 92.63% of the observed variations. Figure 1c showed that cohesiveness increased with the increase in the grape molasses proportion and decreased with an increase in the anhydrous butterfat proportion. The high sugar content of grape molasses can cause an increase in cohesiveness. This observation was similar to the results found by Yildiz *et al.*[23], who studied the textural characteristics of a traditional product composed of water, molasses and starch. The strength of intermolecular interactions within a material affects cohesiveness[24]. Interactions between sugar and water in the grape molasses phase can make the cream more cohesive. Lecithin provides the dispersion of the oil phase into the water phase homogeneously. The emulsifying effect of lecithin could be a reason for the decrease in cohesiveness. This ability could cause a decrease in sugar-water interactions, thus decreasing the cohesiveness. The sticky structure of lecithin came into prominence when more than 2% lecithin was added, causing an increase in cohesiveness. Aloui *et al.*[25] studied the optimization of oil retention in sesame-based halva using emulsifiers and fibres. They reported that there were no statistically significant differences ($p>0.05$) between the standard sample and emulsifier-enriched halva sample with regards to their hardness, cohesiveness, elasticity, and adhesion.

Effect of proportions of the components on work of cohesion of molasses cream

Work of cohesion, which is defined as an index of viscosity[21,26] and work of adhesion[4], is the area of the negative region of the force-time curve in the back extrusion method. The increase in work of cohesion caused a decrease in the spread ability of the cream[21]. Furthermore, it is highly associated with viscosity, cohesiveness and consistency of sample. As shown in Tables 3 and 4, the insignificant lack of fit and high R^2 values of the quadratic model was compatible with each other. In terms of L-pseudo-components, the regression model of work of cohesion could be obtained using the estimated coefficients in Table 4.

Similar to cohesiveness, the work of cohesion was in direct proportion to the molasses, while inverse proportion to the anhydrous butterfat and lecithin (Fig. 1d). Molasses is the most important component, as it had the largest proportion in the molasses cream formula. Therefore, increases in the molasses proportion lead to an increase in the cohesiveness and work of cohesion. The effect of lecithin is less than the other ingredients because it has the lowest proportion in the formula (0.5-2.5%).

Correlation between the responses

The correlation coefficients between the textural attributes of the molasses cream were presented in Table 5. Since hardness and consistency were calculated from the positive region of the force-time curve, and cohesiveness and work of cohesion were calculated from the negative region of the force-time curve, positive and negative groups occurred in Table 5. All of the components are highly correlated with each other ($R^2>0.86$); however, the differences between the mean values of the hardness-consistency ($p<0.05$), hardness-cohesiveness ($p<0.05$), consistency-work of cohesion ($p<0.05$) and cohesiveness-work of cohesion ($p<0.01$) were found significantly different. Muego *et al.*[27] studied the textural attributes of two different samples (peanut butter and peanut paste) using penetration, compression, and texture profile analysis. The researchers reported that the applied tests could differentiate between the textural characteristics of the studied samples.

Optimization of the basic formulation of the molasses cream

It is emphasized that low cohesive emulsions exhibit high stability because the particles tended to disperse properly in the continuous phase[28]. It was reported that oil-in-water emulsions stabilized by soy lecithin alone were stable at pH ranging from 3.5 to 7 due to a relatively strong electrostatic repulsion

Table 5 — Correlation coefficients between the textural attributes of the molasses cream

	Hardness	Consistency	Cohesiveness	Work of Cohesion
Hardness	1	0.994 *	-0.940 *	-0.895
Consistency		1	-0.930	-0.895 *
Cohesiveness			1	0.863 **
Work of Cohesion				1

* Significant at $p<0.05$, ** Significant at $p<0.01$

Table 6 — Some physicochemical properties of the molasses cream with optimised formula

Parameters		Result (x̄±SD)
Colour values	L	25.09±1.24
	a^*	3.88±0.33
	b^*	7.20±0.87
Viscosity (cP)		68185.00±1329.20
Water activity (a_w)		0.66±0.00
pH		4.48±0.02
Free fatty acidity (%)		0.19±0.00
Peroxide value (mEq O_2/kg)		0.44±0.03
TBARs value (mg malonaldehyde/kg)		6.34±0.73
HMF (mg/kg)		43.33±1.54

Fig. 2 — The molasses cream with optimised formula

between the droplets[29]. Aloui *et al.*[25] reported that oil bleeding might be prevented by increasing the emulsifier concentration during the storage of halwa at high temperatures. In order to obtain a firm, consistent and therewithal spreadable molasses cream with no visible oil separation on the surface, hardness and consistency were maximized while cohesiveness and work of cohesion were minimized. The optimization procedure was performed considering the ANOVA results and correlation between the responses. As a result, the best mixture was the formulation that contained 29.76% anhydrous butterfat, 67.74% molasses and 2.50% lecithin with desirability equal to 0.947.

Some physicochemical properties of the molasses cream

Considering colour parameters (L, $a*$ and $b*$) presented in Table 6, the molasses phase, which had the highest proportion in the formula (67.75%), was mainly responsible for the colour of the molasses cream. The high redness value of molasses indicates non-enzymatic browning reactions such as the Maillard reaction[30,31]. Therefore, the low redness value of the molasses cream indicated good quality. As viewed in Figure 2, the optimized molasses cream had a slightly bright and brownish colour approved by the panellists.

The high viscosity values of the optimized molasses cream may have been caused by the emulsion formation and the butterfat that was in solid form at analysis temperature (20°C). In comparison with our results, Karaman *et al.*[32], who used the mixture design modelling approach for optimizing the formula of molasses/sesame paste/ honey blend, reported that complex viscosity was in the range of 16.4-8390.0 Pa s. The most effective ingredient on the viscosity might be the molasses phase due to the high sugar content.

pH and a_w values play an important role in the microbial stability of food products. Therefore, these values should be well defined and standardized according to the storage temperature of the products. Considering the mean pH value and a_w of the molasses cream, pathogenic bacteria growth in the cream is not expected. However, the growth of osmophilic yeast such as *Zygosaccharomyces* can change the aroma and texture of the cream. Besides, oil oxidation and non-enzymatic browning reactions are the most important chemical reactions, which affect the quality of the molasses cream.

The free fatty acidity value is also an indicator for the determination of oil oxidation. The low free fatty acidity, peroxide and TBARs value indicated that the heating and mixing treatments in the cream production did not cause significant oxidation in the oil phase. Besides, the antioxidant compounds in the molasses might inhibit and retard oil oxidation[33]. HMF concentration, which is an indicator of excessive heating in foods containing sugars, has been widely used for the assessment of non-enzymatic browning reactions[32,34]. Although safe levels of HMF consumption are not fully elucidated, a person can ingest 30 and 150 mg HMF per day via various food products[35]. The HMF concentration of the molasses cream was found lower than the maximum value (75 mg/kg) specified in the Turkish Food Codex Grape Molasses Communiqué for liquid grape molasses.

Sensory analysis of the molasses cream

The sensory analysis results of the molasses cream, which was prepared by incorporating butterfat, molasses and lecithin at their optimum levels, were presented in Fig. 3. The cream gained a high score (>7.0) in terms of odour, flavour, mouth feel, appearance and overall acceptability while the texture score (6.57) was found slightly lower. This situation may be originated from the nature of the butterfat that started melting at room temperature. Therefore, the

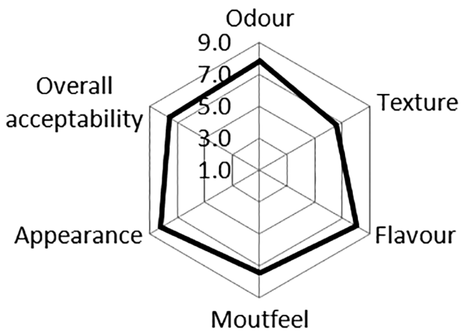

Fig. 3 — Results of sensory analysis of molasses cream

molasses cream showed a less consistent texture with the increase of the temperature in the range of 4-25°C. It was emphasized that short-term stability of emulsions can be provided by using emulsifiers that rapidly adsorbed at the new interface created during emulsification, however long-term stability of the emulsions can be conferred using stabilizers that are effective through either adsorption or non-adsorption mechanism[36]. Therefore, adding a stabilizing agent to the formula can increase the consistency of the cream. Emadzadeh, Razavi, and Schleining[37], who studied dynamic rheological and textural characteristics of low-calorie pistachio butter, reported that the highest consistency value was obtained using xanthan gum in the back-extrusion method.

Conclusion

D-optimal mixture design, which is the most appropriate model for formula optimization, was used based on the determination of textural attributes using the instrumental technique in this study. The proportion of the ingredients (molasses, butterfat and soy lecithin) was found efficient on the studied textural properties (hardness, consistency, cohesiveness and work of cohesion) of the molasses cream. Optimum levels of the proportion of the Sanliurfa butterfat, molasses and soy lecithin were found by numerical optimization technique as 29.76, 67.74 and 2.50%, respectively. In addition, the sensory evaluation results revealed that the instrumental technique is a powerful tool to determine textural characteristics. The cream, which was prepared according to the optimized formula, had a slightly bright and brownish colour, high viscosity and low free fatty acidity, peroxide and TBARS value. Considering the mean pH value and a^w of the molasses cream, the growth of pathogenic bacteria in the cream is not expected. Therefore, the cream is expected to have a long shelf life that is microbiologically safe. However, the oil oxidation and HMF level should be taken into account for the determination of the shelf life. For further studies, the emulsion stability and rheological properties of the molasses cream, which is a traditional product in Turkey, can be determined using surfactants, and its storage stability can be studied.

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Conflict of Interest

The authors declare there is no conflict of interest regarding the publication of this research paper.

Authors' Contributions

ŞÇ has supervised the research study with encouragement, critical feedback, data interpretation, result and discussion, article presentation. NÜ has contributed to the planning of the current research study, writing and conceptualization of the work done. DK has carried out all the experiments related to this manuscript.

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