Production and Characterization of Flavored Dairy Dessert Containing Grape Juice Concentrate

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ABSTRACT: *Grape Juice Concentrate (GJC) contains high amounts of natural sugars, vitamins, and polyphenols so it can be used as a natural sweetener and functional ingredient. The novelty of the present study was to produce flavored dairy desserts, as well as to evaluate the effect of GJC, gelatin, and cream on its physicochemical, mechanical, and sensorial properties. In this study, optimization of breakfast flavored dairy dessert formulation containing GJC was done using design expert and response surface methodology. The effects of cream (75-90 %), gelatin (0 - 0.5 %), and GJC (10-25 %) on the properties of flavored dairy desserts were evaluated. The samples were subjected to fat, acidity, pH, total solids content, sugar content, hardiness, color, antioxidant activity, and sensory attributes. At first, the modeling of responses was done using data regression analysis, and then 3D charts were drawn for each response. The results showed that the samples became firmer, and darker in color as the level of GJC increased. The antioxidant activity of the desserts was increased mostly by GJC level. The maximum hardness and radical inhibitory activity of samples were 1380 g and 73.5%, respectively. The general acceptability of the desserts was affected by the amount of GJC. Based on the standard range of responses and the most desirability, the optimal point was obtained. At the optimal point, the amounts of cream, GJC, and gelatin were 75.05, 20.59, and 4.36% respectively. Flavored dairy desserts could be considered to be a suitable source of vitamins, soluble fiber, antioxidants, amino acids, and a good source of natural sweets.*

KEYWORDS: *Antioxidant; Dairy dessert; Grape juice concentrate; Response surface methodology.*

INTRODUCTION

Dairy creams are oil-in-water (o/w) emulsions, in which solid fat partially formed their dispersed lipid phase. This kind of emulsions can improve their thickness after shaking or whipping [1, 35]. Studies indicated that it is possible to imitate this behavior by improving model of cream-like emulsions prepared with milk protein and vegetable fat [2, 3]. Novel food products are produced by changing traditional product formulas, and replacing or removing and adding certain components [4]. Different flavored milk-based dairy products, with different flavors,

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1021-9986/2021/6/2028-2041 14/$/6.04

textures, and functional properties, are introduced to consumers [5]. Food technology tried to decrease the fat, salt, sugar content, and synthesis ingredient in the foods Due to different health problems [6]. Also, develop different foods containing functional characterization and good taste for increasing consumer health [7, 8, 36].

Researchers have been informed that there is an inverse association between mortality from age-related diseases and consumption of some vegetables and fruits. These phenomena might be due to the high amount of antioxidant compounds, such as phenolic ingredients, in vegetables and fruits [9, 37, 38]. Grape (*Vitis vinifera*) is among the usually consumed fruit, and the demand for this fruit and its products is increasing, partly due to their associated health benefits [10].

Grapes are usually consumed as fresh fruit or can be processed into vinegar, wine, Grape juice Concentrate (GJC), fruit juice, dried grape, jam, pistil, and marmalades [11]. Grape and its products have a lot of polyphenolic components and have high antioxidant activity. They have been studied to show anti-inflammatory and anticancer effects in vitro, as well as the ability to inhibit coronary heart disease and cellular events predisposing atherosclerosis [12-14]. The grape ingredients and its products' components which are presumed to create positive health influences are mainly procyanidins, flavonols, phenolic acids, and anthocyanins [15, 16]. Some application of grape juice in food products was reported by *Hossain et al.* (2012) in yogurt [39], *Park et al.* (2014) in *Yanggaeng* [40], and *Corrêa et al.* (2014) in guava jam [41].

However, to our knowledge, the current work is the first report in which flavored dairy dessert containing grape juice concentrate. The present study aimed to produce flavored dairy dessert containing GJC, as well as evaluate the effect of GJC, gelatin, and cream on its physicochemical, technological, and sensorial properties. Finally, optimization of the dessert formula Containing Grape Juice Concentrate will be carried out on the basis of acceptability using response surface methodology.

EXPERIMENTAL SECTION

Raw materials

GJC containing 60 % dry matter, 1.8 % ash, acidity (0.71 % tartaric acid), and pH 5.2 was prepared from the local market (Sarvestan, Iran) in September 2018. Gelatin was prepared by Merck Company, (Germany). Milk protein concentrate containing protein (30% w/w), fat (0.2 %), and dry matter (96 %) was purchased from the Fars-Pegah Co. (Shiraz, Iran). Milk fat was obtained from Fars-Pegah Co. (Shiraz, Iran). Mono and diglyceride were purchased from Danisco Co. (Kunshan, China).

Experimental design

In the current investigation, the effects of the cream (75-90 %), GJC (10-25 %) and gelatin (0-0.5 %) on the properties of dessert were evaluated using RSM. Treatment was prepared in six levels and set by Design Expert v_{11}. The batch runs were conducted in D-optimal designed experiments. The experimental design was implemented according to raw material Percentage, as follows:

Run 1: 90 % Cream + 10 % GJC + 0 % Gelatin
Run 2: 86.13 % Cream + 13.7 % GJC + 0.13 % Gelatin
Run 3: 90 % Cream + 10 % GJC + 0 % Gelatin
Run 4: 75 % Cream + 25 % GJC + 0 % Gelatin
Run 5: 82.25 % Cream + 17.25 % GJC + 0.5 % Gelatin
Run 6: 89.4 % Cream + 10 % GJC + 0.5 % Gelatin
Run 7: 75 % Cream + 24.4 % GJC + 0.5 % Gelatin
Run 8: 82.25 % Cream + 17.25 % GJC + 0.5 % Gelatin
Run 9: 75 % Cream + 24.4 % GJC + 0.5 % Gelatin
Run 10: 89.65 % Cream + 10 % GJC + 0.25 % Gelatin
Run 11: 78.7 % Cream + 20.1 % GJC + 0.4 % Gelatin
Run 12: 75 % Cream + 25 % GJC + 0 % Gelatin
Run 13: 75 % Cream + 24.75 % GJC + 0.25 % Gelatin
Run 14: 82.45 % Cream + 17.45 % GJC + 0 % Gelatin
Run 15: 89.4 % Cream + 10 % GJC + 0.5 % Gelatin
Run 16: 78.7 % Cream + 21.13 % GJC + 0.13 % Gelatin
Run 17: 82.35 % Cream + 17.35 % GJC + 0.25 % Gelatin

Emulsion preparation

A cream containing 30 % (w/w) milk fat prepared by application mono-and diglyceride emulsifier, stabilizer, and milk powder, 1%, 0.04%, and 3 %, respectively. Firstly, Milk powder was dissolved in water and Mono- and diglyceride was combined with milk fat. Cream production was done by using an Ultra-Turrax T45 disperser homogenizer; for 4 min at 70 °C and 10000 rpm. After that gelatin was dispersed in GJC and added to the mixture and homogenized for 2 min at 75°C and 10000 rpm. Before characterization tests, samples were kept at 2°C overnight. Formulations (100 g) were prepared in 3 replicates [17].

Chemical Composition analysis

Moisture, fat, and sucrose content of samples were measured according to the method of *Almanza-Rubio et al.* (2016) [18]. Total titratable acidity and pH of flavored dairy desserts were measured by *Bemer et al.* (2016) method and its report based on lactic acid percentage [19].

Antioxidant activity determination

The antioxidant activity was measured by 2, 2-diphenyl-1-picrylhydrazyl free radicals (DPPH°) based on the method modified by *Asl et al.* (2018). First, dessert samples (0.2 mL) were homogenized with methanol (0.8 mL). Then, each diluted sample (0.5 mL) was homogenized thoroughly with 0.1 mM DPPH° solution (1.5 mL). The mixture was kept at 25 ºC for 60 min in a dark place and the decrease of DPPH° absorbance was measured by reading at 517 nm [20]. The DPPH° inhibition activity was calculated according to the Eq (1):

$$\text{DPPH inhibition activity}(\%) = \left[\left(A_{\text{control}} - A_{\text{sample}}\right) / A_{\text{control}}\right] \times 100 \quad (1)$$

Texture profile analysis

The hardness of the flavored dairy dessert was determined using a texture analyzer (Brookfield, USA) by a compression test. The sample was compressed using a cylinder probe of 25 mm diameter to 10 mm penetration depth with 1 mm/s pre and post-test speed and 1 mm/s test speed [21].

Colour analysis

For evaluation of the color parameters of flavored dairy desserts, the digital colorimetry technique was used. The surface color of samples was determined by a digital Canon camera. The resulted pictures were studied by Adobe Photoshop CS 6 Software and main color parameters such as L*, a*, and b* were extracted [22].

Sensory analysis

Five points hedonic test was used to evaluate the sensorial properties of flavored dairy dessert. Main parameters including color, texture, odor, taste, and general acceptance were analyzed by the panelist. Samples were randomly coded and placed for 30 minutes at room temperature and then evaluated by thirty trained students of the food science and technology department (Sarvestan Branch, Islamic Azad University, Iran). The scale of the method was 1 to 5, dislike, dislike moderately, moderate, like moderately, and like [23].

Statistical analysis

For analysis of the results of the Experiment Design Expert 11 was used. The analysis of variance (ANOVA) was applicated for the comparison of averages. The quadratic model was statistically fitted with respect to the calculation coefficient (R^2). Finally, Optimization of flavored dairy desserts, based on the acceptability was done.

RESULTS AND DISCUSSION

Based on the findings of our preliminary experiments, for optimization physicochemical, textural, and sensorial properties of flavored dairy dessert, cream, GJC, and gelatin concentrations were determined for further D-optimal experiments. The quadratic models between flavored dairy dessert properties and the used treatments were taken by Design-Expert software as shown in Table 1. The ANOVA analyses were done to calculate the significant level of 2FI regression model. The results showed that 2FI regression model was statistically significant based on Fisher's F-test, *F*-value, and *P*-value ($P < 0.001$) of the model. Also, this result was confirmed by the calculation of coefficients (R^2) and lack-of-fit factor. The P-value is used as an agent for controlling the significance of all coefficients. According to the ANOVA, it can be concluded that the 2FI polynomial model with low P-values was statistically significant.

Chemical properties

The pH, acidity, dry matter, sucrose and fat content showed a considerable variation from 5.80 to 6.23%, 0.19 to 0.22 %, 38.65 to 43.74 %, 3.25 to 7.65 %, and 23.80 to 27.00 %, respectively. The value of the calculated coefficient adj-R^2 of pH, acidity, dry matter, sucrose, and fat content (0.95, 0.96, 0.78, 0.98, and 0.99, respectively) showed that only about 5, 4, 22, 2, and 0.01% for optimization of pH, acidity, dry matter, sucrose and fat content of flavored dairy dessert of the total variation couldn't be described by this model. The *F*-values for lack-of-fit were 1.34, 1.16, 11.48, 5.16 and 0.61 while the corresponding *P*-values were 0.37, 0.43, 0.01, 0.04 and 0.70 for optimization of pH, acidity, dry matter, sucrose

Table 1: Predictive models for properties of flavored dairy dessert.

Responses	Predictive models	adj-R^2	F-value of model	Probability for Lack of Fit
pH	+ 3.41235 + 0.030329A + 0.001700B + 5.70452C + 0.000038AB - 0.055532× AC - 0.061637BC	0.95	49.71	0.38
Acidity (Lactic acid %)	- 0.378298 + 0.005640A + 0.010376B + 2.54318C - 0.000047AB - 0.025371AC - 0.026848BC	0.96	67.08	0.44
Dry matter (%)	- 221.83754 + 2.59276A + 3.34188 B + 687.40032 C - 0.006876 AB - 6.82275 AC - 7.03107 BC	0.78	10.66	0.01
Sucrose (%)	- 136.62819 + 1.37514 A + 1.64120 B + 299.35070C- 7.97153E-06 AB - 2.99818 AC - 2.99509 BC	0.98	130.23	0.05
Fat (%)	+ 38.25491 - 0.074910 A + 0.160387 B - 99.81322C- 0.006827 AB + 0.995556 AC + 1.00849 BC	0.99	871.07	0.70
Radical inhibitory (%)	+ 5.86560 + 0.628368 A + 3.63258 B + 131.46071 C - 0.037890 AB - 1.43435 AC - 1.34743 BC	0.91	28.89	0.06
Hardness (g)	- 12121.56888 + 131.46215A + 281.66388 B - 5902.97216C -2.46399AB + 84.40292AC + 23.47993BC	0.84	14.7	0.34
L*	+ 271.87941 - 1.81755 A - 0.123148 B - 441.73174 C - 0.040371 AB + 4.53867 AC + 4.24351 BC	0.86	17.47	0.06
a*	- 109.82682 + 1.12264 A + 2.43508 B + 9.61402 C - 0.017016 AB - 0.090080 AC + 0.089557 BC	0.77	9.75	0.69
b*	- 441.57612 + 4.68965 A + 7.66269 B + 791.33901 C - 0.035739 AB - 7.97076 AC - 7.82600 BC	0.94	41.89	0.31
Sensory (color)	- 75.78051 + 0.767419 A + 0.810197 B + 269.19148 C + 0.001478 AB - 2.66480 AC - 2.83249 BC	0.62	5.27	0.82
Sensory (texture)	- 78.63038 + 0.796990 A + 0.015988 B + 392.61351 C + 0.011131 AB - 3.92778 AC - 3.83838 BC	0.68	6.54	0.15
Sensory (odor)	- 15.14207 + 0.169002 A + 0.019447 B + 68.93328 C + 0.003627 AB - 0.693641 AC - 0.719316 BC	0.96	57.88	0.01
Sensory (taste)	+ 128.82122 - 1.28664 A - 1.84329 B - 76.64227 C + 0.009576 AB + 0.748578 AC + 0.784424 BC	0.80	11.89	0.16
Sensory (acceptability)	- 13.79547 + 0.151264 A - 0.434599B + 134.56571 C + 0.008842 AB - 1.36689 AC - 1.17738 BC	0.56	4.38	0.01

and fat content, respectively, which implied the lack of- fit was not statistically significant relative to the pure error because of noise. No significant lack-of-fit corroborated the model validity (Table 1). The effects of cream, GJC, and gelatin on the pH, acidity, dry matter, sucrose, and fat content of flavored dairy desserts are shown in Fig. 1. Based on the results, an increase in cream and gelatin concentration significantly increases the pH of the sample. But increase in GJC significantly decreased the pH of flavored dairy desserts. The results of acidity showed that an increase in GJC concentration significantly increases the acidity of the sample. The addition of more GJC in the formulation reduced significantly ($p< 0.05$) the pH of samples while increasing titratable acidity (% lactic acid). The reduction of pH by adding GJC in the formulation may be because of the GJC pH (pH of GJC is 5.2 and pH of milk is 6.7). Also, GJC has high amounts of vitamins (C and E) and is a suitable source of antioxidants these ingredients are acidic in nature, including organic acids and phenolic compounds [13]. *Jahromi* and *Niakousari* (2018) produced and evaluated a milk- based dessert with fig paste and CMC. They reported with increasing fig, pH was significantly reduced and titratable acidity significantly raised and this phenomenon is because of chemical ingredients of fig such as polyphenols and fatty acids [4]. Fig. 1 showed that the various quantities of cream and GJC significantly raised the dry matter of samples ($p< 0.05$). It's due to the increase of cream and GJC amount in the formulation. *Majzoobi et al.* (2016), produced the dairy dessert formulated using wheat germ. They showed that wheat germ is a good source of amino acids (such as aspartic acid and glutamic acid) and fatty acids as well as antioxidants with acidic nature which can decrease the pH of the desserts [24]. Also based on results reported

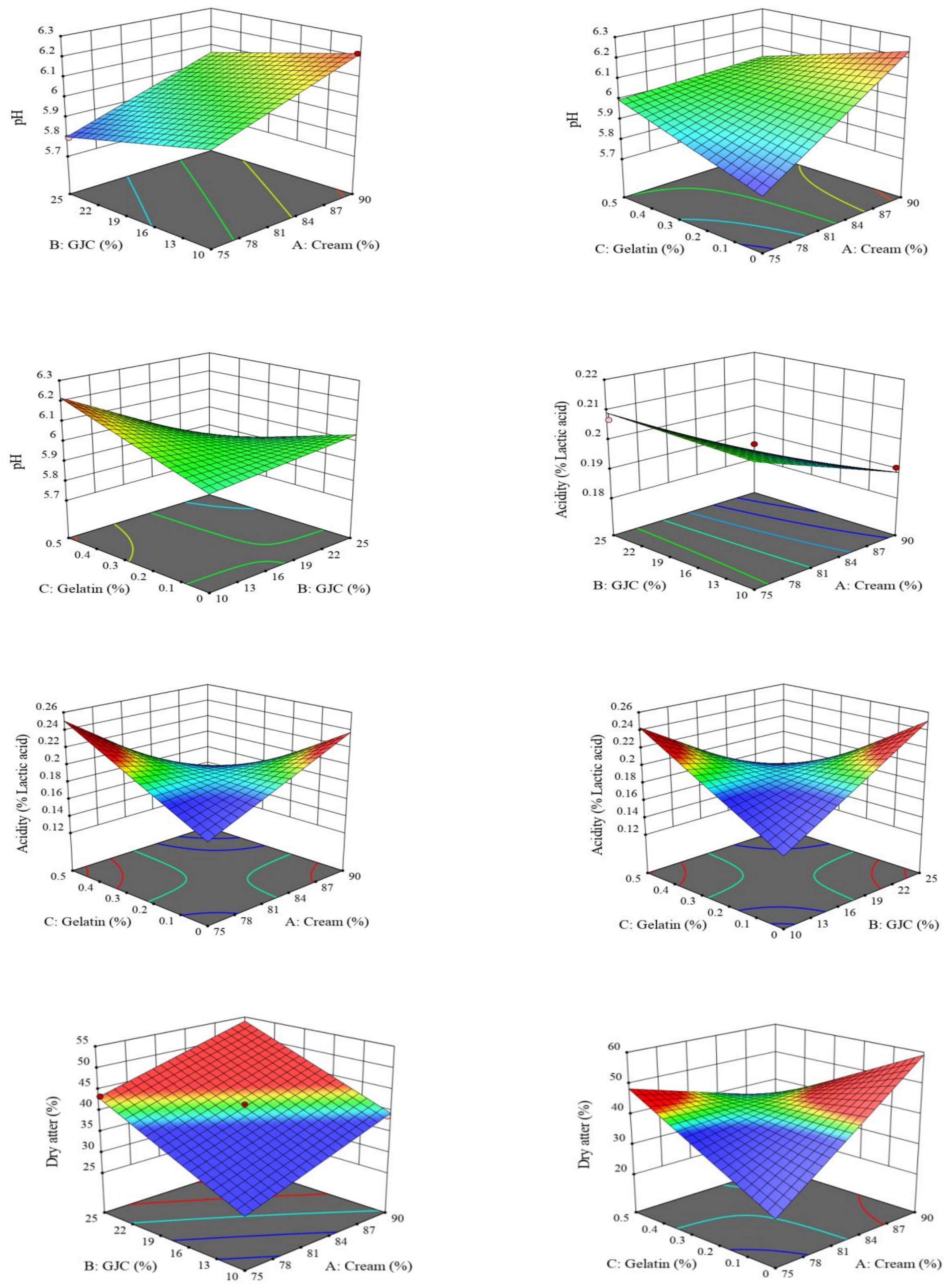

Fig. 1: Effects of grape juice concentrate (GJC), gelatin, and cream on physicochemical properties of flavored dairy dessert.

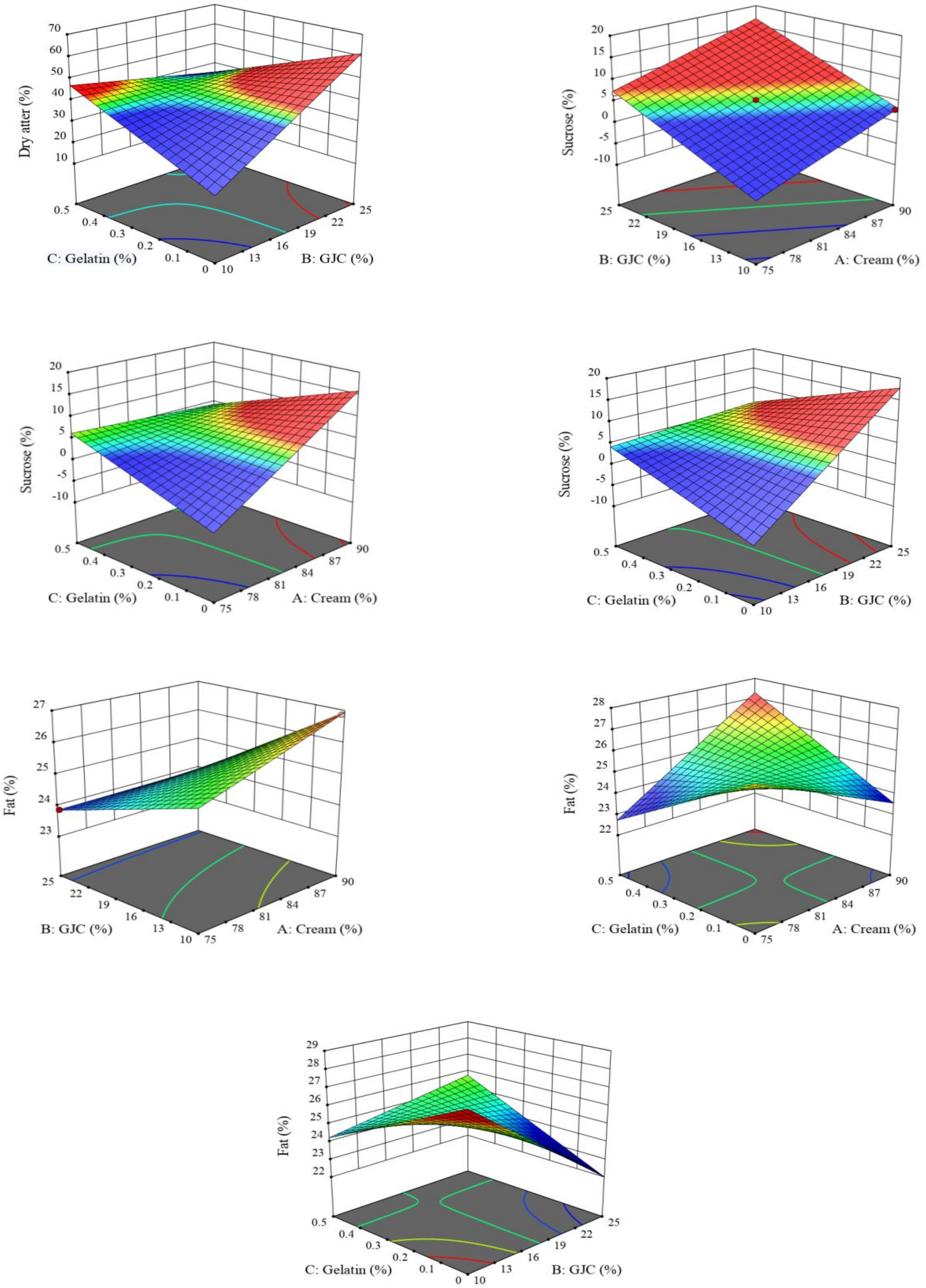

Fig. 1: Effects of Grape Juice Concentrate (GJC), gelatin, and cream on physicochemical properties of flavored dairy dessert.

in Fig 1, an increase in cream and gelatin concentration significantly increases the sucrose content of the sample. According to the response surface plot, with an increase in cream concentration significantly increases the fat content of the sample. But increase in GJC significantly decreased the fat content of flavored dairy desserts.

Antioxidant activity

The radical inhibitory activity showed a considerable variation from 59 to 73.5 %. The value of the calculated coefficient adj-R^2 (0.91) showed that only about 9 % for optimization of the hardness of flavored dairy dessert of the total variation couldn't be described by the model. The *F*-value for lack-of-fit was 4.48 while the corresponding *P*-value was 0.06 (P >0.05) for optimization of radical inhibitory activity, which implied the lack of- fit was not statistically significant relative to the pure error because of noise. Insignificant lack-of-fit certified the validity of this model (Table 2). The effects of cream, GJC, and gelatin on the radical inhibitory activity of flavored dairy desserts are shown in Fig. 2. The results of radical inhibitory activity showed that with an increase in GJC significantly increases the radical inhibitory activity of the sample. *Castilla et al.* (2006), determined the antioxidant activity of concentrated red grape juice; they showed concentrated red grape juice contains a high amount of vitamins C, E, and polyphenols and has suitable antioxidant activity [13]. *Capanoglu et al.* (2013), studied the polyphenol concentration and grape juice antioxidant activity concentrate. They reported main anthocyanins determined using PDA-LC-MS: monoglucosides of delphinidin, petunidin, cyanidin, peonidin, and malvidin, in addition to malvidin acetylglucoside, malvidin coumaroylglucoside, and peonidin coumaroylglucoside [25]. *Hossain et al.* (2012) reported that the addition of grape juice improved the antioxidant activity of yogurt because of the high antioxidant ingredient in the grape [39]. A similar result about improving antioxidant activity of food products by grape juice was reported by *Park et al.* (2014) on the *Yanggaeng* [40] and *Corrêa et al.* (2014) on the guava jam [41].

Texture property

The hardness analysis showed a considerable variation from 135 g to 1380 g. The value of the calculated coefficient adj-R^2 (0.84) showed that, only about 16% for optimization of the hardness of flavored dairy dessert

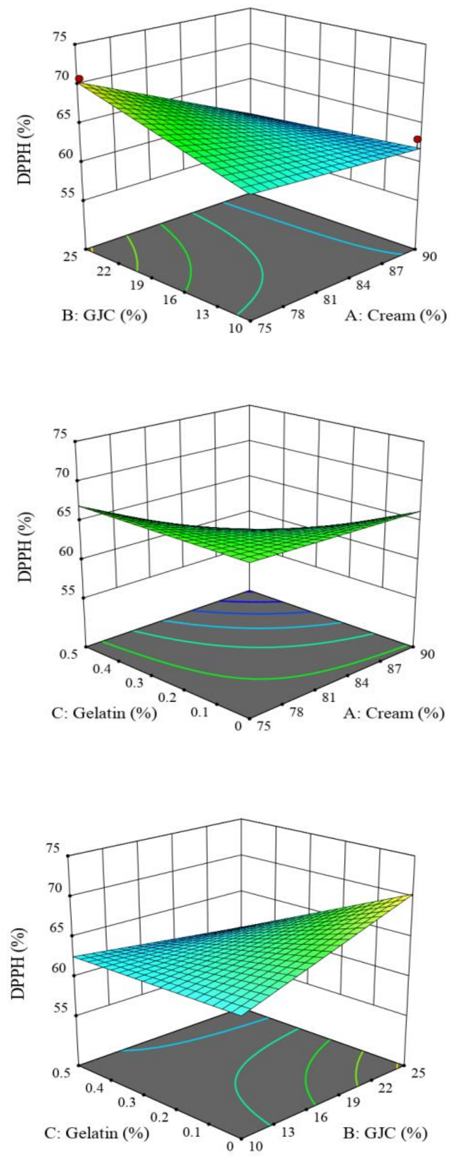

Fig. 2: Effects of grape juice concentrate (GJC), gelatin, and cream on the radical inhibitory activity of flavored dairy dessert.

of the total variation couldn't be described by the model. The *F*-value for lack-of-fit was 1.47 while the corresponding *P*-value was 0.34 (P>0.05) for optimization of hardness, which implied the lack of- fit was not statistically significant relative to the pure error because of noise. Insignificant lack-of-fit certified the validity of this model (Table 1). The effects of cream, GJC, and gelatin on the hardness of flavored dairy dessert are shown in Fig. 3. According to the response surface plot, with raise in cream, gelatin, and GJC significantly increases the hardness of the sample. Any raise in the hardness and firmness of emulsion containing biopolymers is usually because of the interaction between biopolymers and molecules of water [26]. Also, the high concentration of GJC in the sample (its containing a high concentration of insoluble and soluble fiber) and the ability of dietary fiber to interact with a water molecule in the structure of food could lead to a rise in the hardness [27, 28]. Our findings are similar to data reported by *Arcia et al.* (2010), *Ayar et al.* (2009), and *Bayarri et al.* (2009), while producing different types of dairy desserts containing hydrocolloids and fruits [29-31].

Corrêa et al. (2014) evaluated the rheological properties of guava jam with added concentrated grape juice. They reported that the addition of concentrated grape juice improved the rheological properties of the sample because of the ingredients and rheological properties of concentrated grape juice [41]. *Park et al.* (2014) evaluated the quality characteristics of Yanggaeng combined with grape juice. They reported that the hardness of samples significantly increased after the addition of grape juice [40].

Colour properties

The L*, a*, and b* showed a considerable variation from 58 to 74, 0 to 7, and 22 to 36, respectively. The value of the calculated coefficient adj-R^2 of L*, a*, and b* (0.86, 0.77, and 0.94, respectively) showed only about 14, 23, and 6% for optimization of L*, a*, and b* of flavored dairy dessert of the total variation couldn't be described by the model. The *F*-values for lack-of-fit were 4.44, 0.61, and 1.61 while the corresponding *P*-values were 0.06, 0.69, and 0.31 (P>0.05) for optimization of L*, a*, and b*, respectively, which implied the lack of- fit was not statistically significant relative to the pure error because of noise. An insignificant lack-of-fit confirmed the validity of the model (Table 1). The effects of cream, GJC, and gelatin on the L*, a*, and b* of flavored dairy desserts are shown in Fig. 4. According to the response surface plot, with an increase in GJC significantly decreased the L* of the sample. The results of a* and b* showed that with an increase in cream and GJC significantly increased a* and b* of the sample. The color difference in the various formula could be due to the brown pigments and yellow color of GJC. Also, the higher concentration of GJC in the formulation (increasing the content of dry matter) increased the

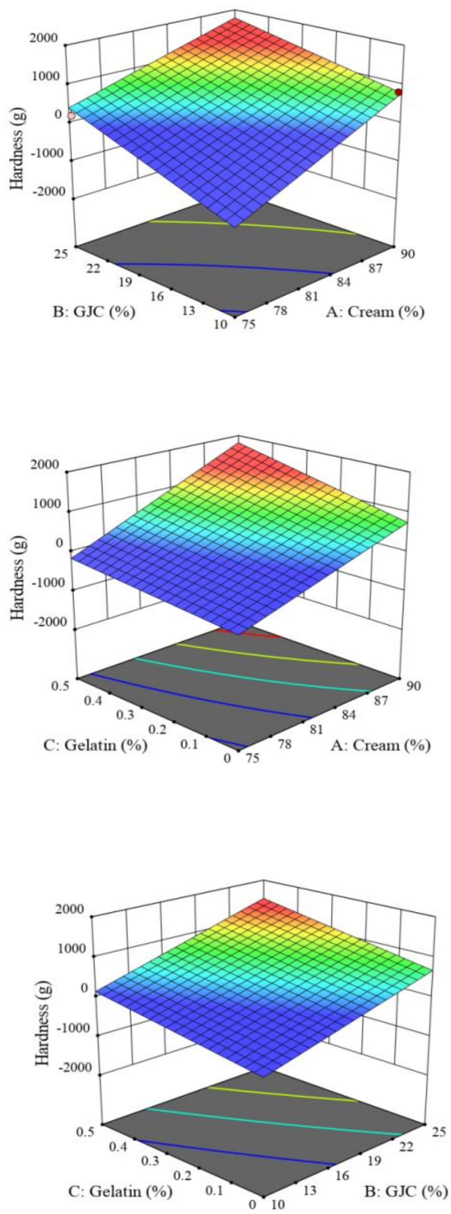

Fig. 3: Effects of grape juice concentrate (GJC), gelatin and cream on hardness of flavored dairy dessert.

absorption of light and thus reduced lightness of samples [32]. *Jahromi* and *Niakousari* (2018) reported with increasing fig amount in the formulation resulted in significantly decreased L* and raised a* and b*[4]. The interaction of GJC components (proteins, carbohydrates, and fibers) with the proteins of milk in the sample may decrease the light scattering influence of the sample. The similar data have been shown by *Majzoobi et al.* (2016) [24].

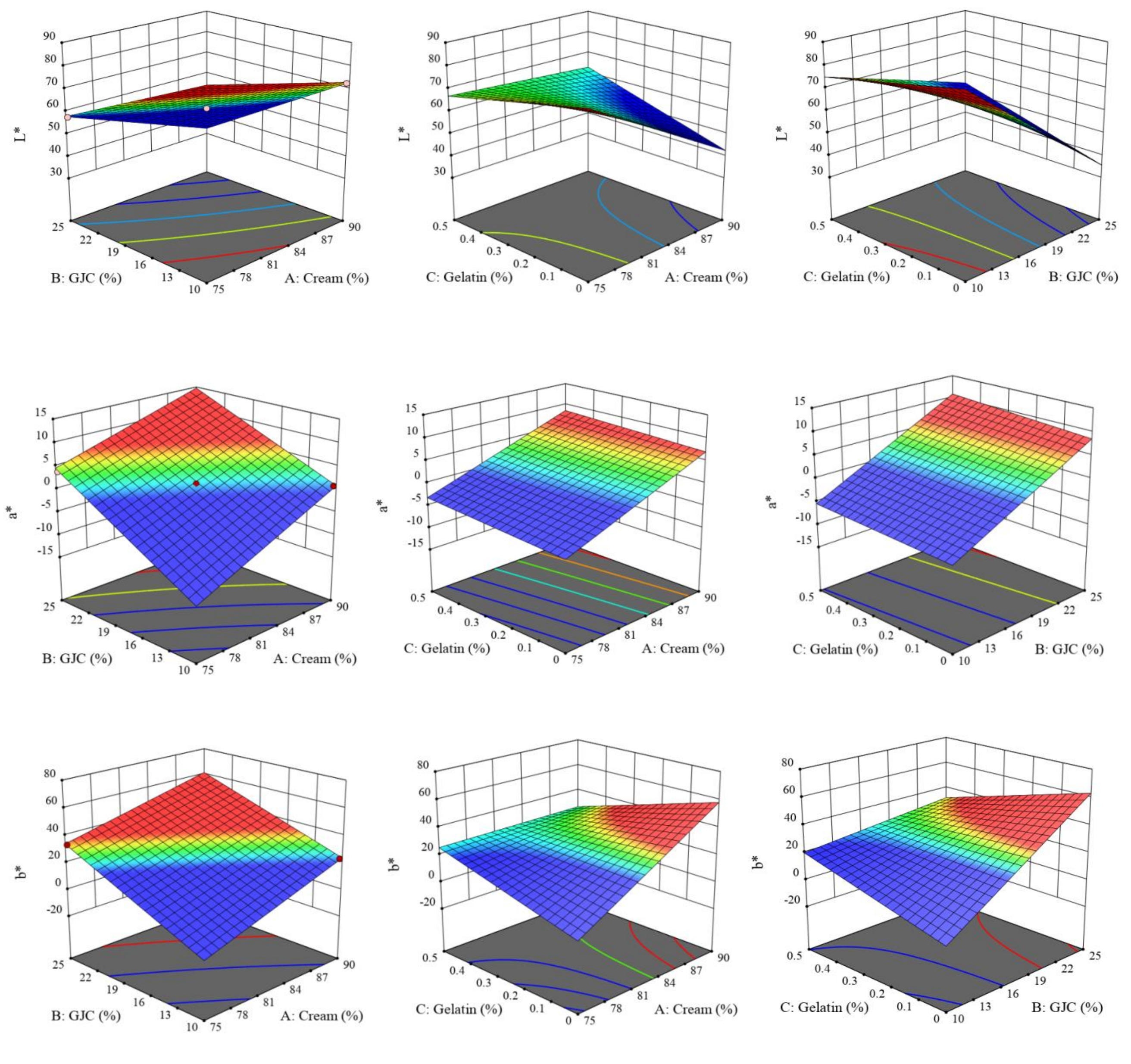

Fig. 4: Effects of grape juice concentrate (GJC), gelatin, and cream on color properties of flavored dairy dessert.

Sensorial properties

The result of color, texture, odor, taste, and acceptability showed a considerable variation from 2.5 to 4.8, 2.11 to 4.7, 3.15 to 4.92, 3 to 4.89, and 3 to 4.75, respectively. The value of the reported coefficient adj-R^2 of color, texture, odor, taste, and acceptability (0.62, 0.68, 0.96, 0.80, and 0.56, respectively) showed that only about 38, 32, 4, 20, and 44% for optimization of color, texture, odor, taste, and acceptability of flavored dairy dessert of the total variation couldn’t be described by the model. The *F*-value for lack-of-fit were 0.41, 2.64, 9.78, 2.60, and 15.51 while the corresponding *P*-values were 0.82, 0.15, 0.01, 0.16 and 0.01 for optimization of color, texture, odor, taste and acceptability, respectively, which concluded the lack-of-fit was not statistically significant relative to the pure error because of noise. An insignificant lack-of-fit showed the validity of the model (Table 1). The effects of cream, GJC, and gelatin on the color, texture, odor, taste, and acceptability of flavored dairy desserts are shown in Fig. 5. According to the response surface plot,

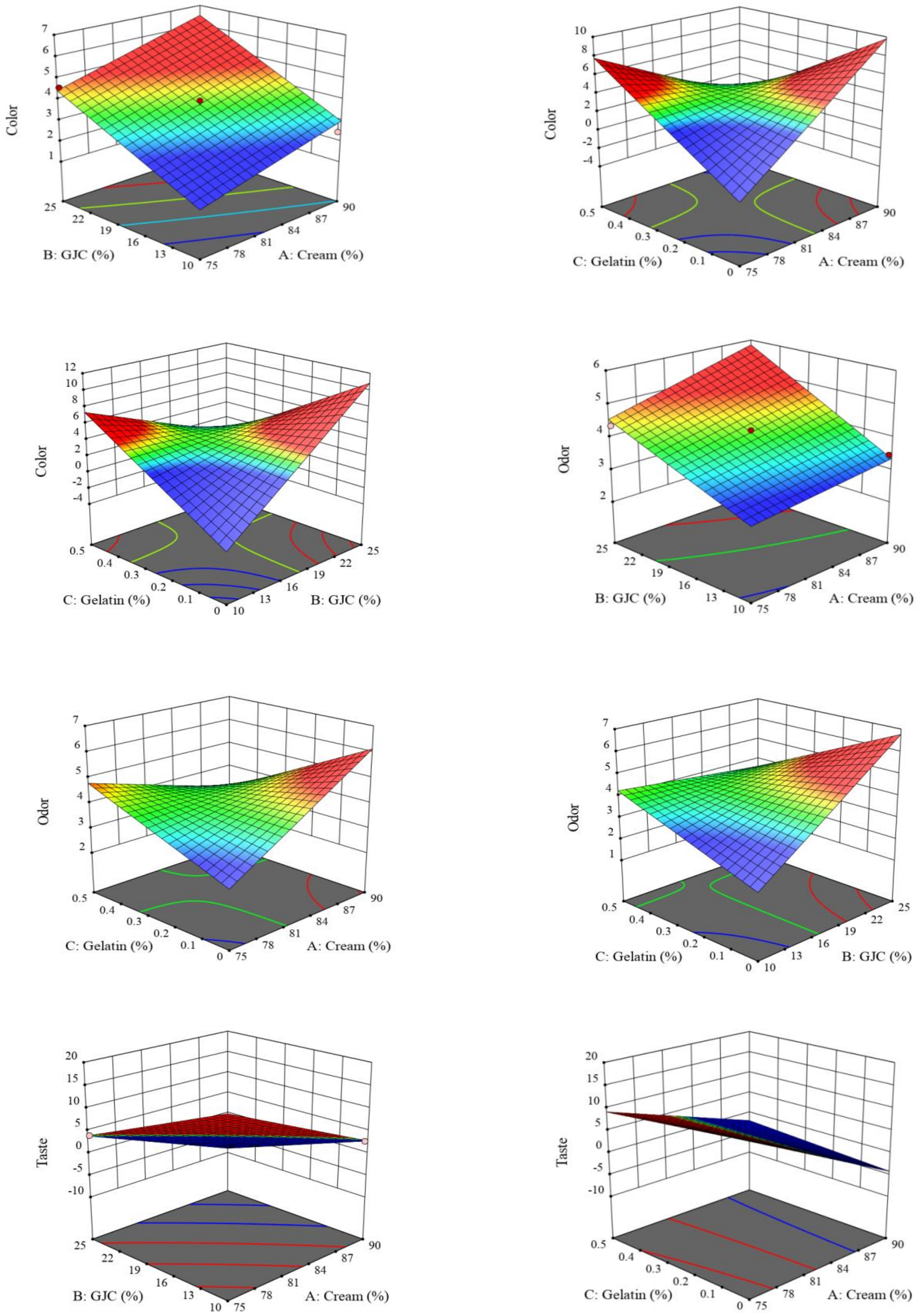

Fig. 5: Effects of grape juice concentrate (GJC), gelatin, and cream on sensorial properties of flavored dairy dessert.

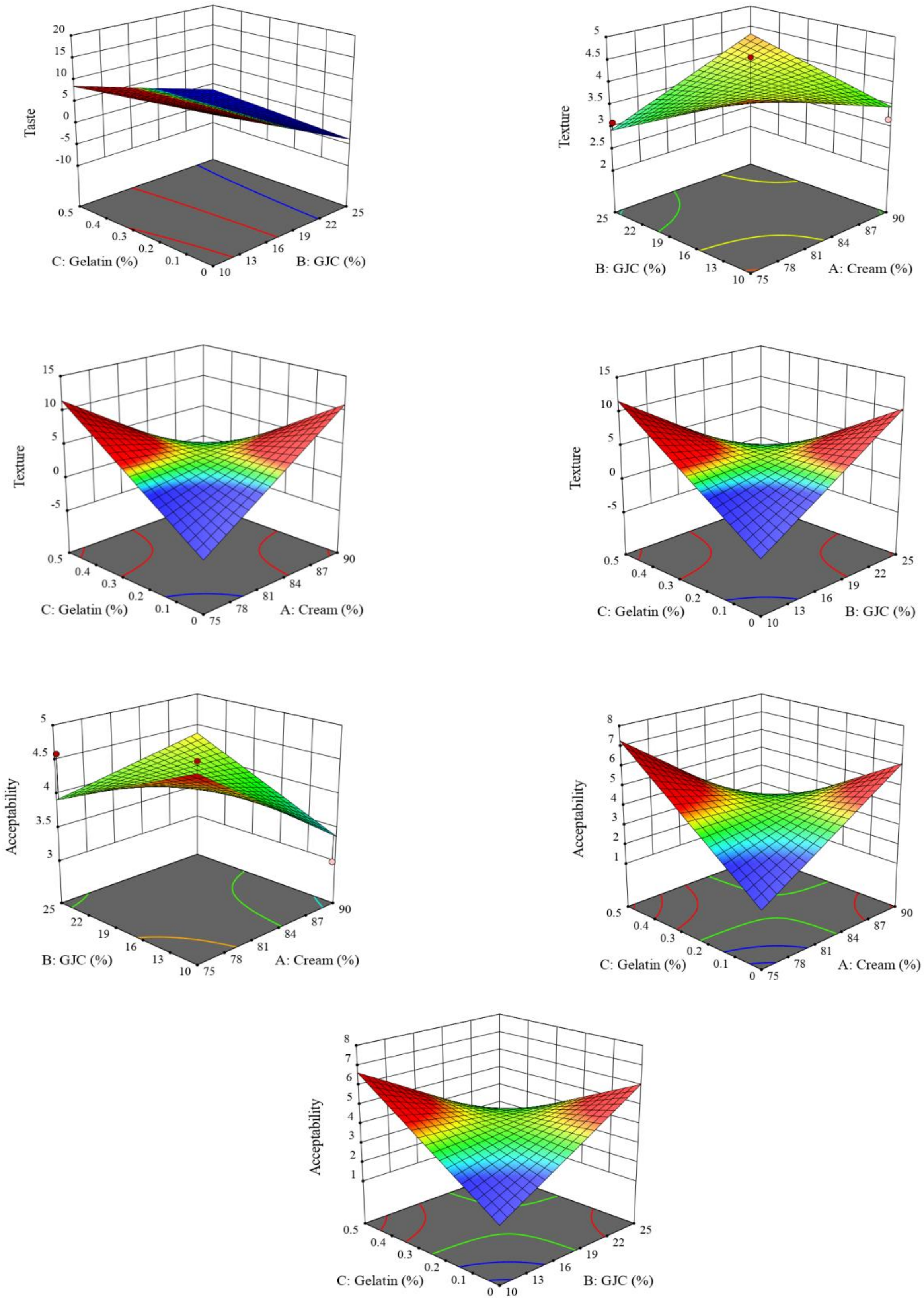

Fig. 5: Effects of grape juice concentrate (GJC), gelatin, and cream on sensorial properties of flavored dairy dessert.

with an increase in cream, gelatin and GJC significantly increased the color, texture, odor, and acceptability of the sample. But with increasing the GJC, taste significantly decreased. Odor, taste, and acceptability values for dessert are between 3 and 5, showing that all desserts can be placed in the acceptability range (≥3 moderate to like). Low texture acceptability in some samples may be related to the suspension effect and their decreased viscosity, which was because of the absence of gelatin and the presence high amount of GJC. In fruit-based foods, appearance and color are the main factors of perceived initial acceptability and quality. Researchers are believed that suitable appearance and color improve products' potential to be consumed and purchased [33, 34]. The taste results showed that panelists usually liked desserts containing a high amount of GJC. The scores of samples for taste significantly ($P < 0.05$) raised in the dessert containing high content of GJC. Based on results of general acceptability, GJC, gelatin, and cream influenced the flavored dairy dessert in a positive manner. *Hossain et al.* (2012) reported that the addition of grape juice improved the sensorial properties of yogurt [39]. Also, *Park et al.* (2014) reported that the sensorial properties of *Yanggaeng* after the addition of grape juice were improved [40].

Based on the sensory properties of flavored dairy dessert numerical optimization was performed and the optimal point with the highest desirability was obtained with the percentage of independent variables of cream, GJC, and gelatin, 75.05, 20.59, and 4.36% respectively.

CONCLUSIONS

Production of flavored dairy desserts with GJC can improve the nutritional, functional, and antioxidant activity of the sample. The best formulation of flavored dairy dessert based on GJC was developed by Design-Expert software. Amounts of GJC, cream, and gelatin had significant effects on the physicochemical properties of flavored dairy desserts. GJC had significant effects on the main parameters including texture, color, and sensorial properties. The firmness and overall acceptability were significantly improved by the addition GJC. The most acceptable dessert was produced with 75.05, 20.59, and 4.36 % of the cream, GJC, and gelatin, respectively. This product is a good bar with high content of different vitamins, soluble fiber, antioxidants, amino acids, and natural sweets. Also, a food manufacturer can use the information from this research to improving the techno-functional properties of their products.

Received : Apr. 4, 2020 ; Accepted : Jul. 30, 2020

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