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Effects of Quince Seed Mucilage and Guar Gum on the Physicochemical and Sensory Properties of Doogh

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ABSTRACT

Iranian famous drinking yoghurt type, named Doogh, is a fermented dairy beverage and constituts an important part of daily beverage consumption in Iran. Doogh is commonly produced from mixing of yoghurt, drinking water, salt, and essence of aromatic vegetables such as thyme, mint, and oregano. In the present work, the effects of Quince seed mucilage [Qm: 0-0.1% (w/w)], Guar gum [Gg: 0-0.2% (w/w)] and storage time (1-21 days) on the physicochemical (pH, acidity and viscosity) and sensory properties of Doogh were studied. The Doogh was stored at 4°C for 21 days to be evaluated. Quince seed mucilage and guar gum were added to Doogh based on a Central Composite Design (CCD). The Response Surface Method (RSM) was applied to find out the optimum conditions and interaction between different factors. Three factors including Doogh storage time and added percentages of Qm and Gg were investigated. The results showed that the optimum condition of factors was different based on response. Based on viscosity of the Doogh, the first day of Doogh production and 0.1% (w/w) of Qm and 0.2% (w/w) of Gg were the best condition.

Keywords: Central composite design, Doogh viscosity, Response Surface Method (RSM), Yoghurt.

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INTRODUCTION

Doogh as an acidified milk drink is produced by adding salt (maximum 1%) and water (50–60%) into yoghurt (40–50%) and it is characterized by a pH< 4.5 and nonfat solids more than 3.2 wt% (Gorji *et al*., 2011). Consumption of this drink is very common in Asia and there are clear differences between Doogh (yoghurt based beverage) and similar products which are nowadays consumed in Europe due to the presence of added edible salt as well as viscosity (Azarikia and Abbasi, 2010). Food hydrocolloids or gums are added to food systems for numerous reasons, mainly to modify the texture, increase the stability, or reduce the fat or calories of a product. Specifically, food hydrocolloids are used to thicken agent, gel, and control syneresis. Stabilize an emulsion or suspension affects the rheological properties of food (Ghanbari and Farmani, 2013; Sadat *et al*., 2015.). Use of food hydrocolloids continues to increase with the recent development of low-fat and reduced-fat products (Sadar, 2004). Quince, which grows as a shrub in the wild, is a small tree only about 3-4 m high. The seeds are extensively used, on account of the mucilage of outer surface. Quince seed mucilage affords an additional example of the natural occurrence of methoxyuronic acids. Quince seed mucilage is a complex of a cellulosic fraction with a more readily hydrolyzed polysaccharide. The linkage is not easily broken by the action of dilute acid or alkali at room temperature, but hot dilute acid liberates reducing sugars, cellulose, and a gum. Arabonose, a mixture of methylated and unmethylatedaldobionic acids and a cellulosic fraction were liberated in the hydrolysis of quince seed gum (Tamri *et al*., 2014). Xylose

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was identified in the further hydrolysis of the aldobionic acids (Fekri *et al*., 2008). There are many reports on the stabilization of acidified milk drinks using different kinds of hydrocolloids. One of the most popular gums is pectin, which has been widely used as a stabilizer. Many studies have been done about pectin and its effective mechanism of stabilization (Tromp *et al*., 2004).

Gums are high molecular weight polysaccharides which are dissolved in solvent like water. Gels or viscous solutions produce the plant exudates, marine algae and bacteria. (Rahimi *et al*., 2012). The guar gum is one of the best gums that is used in the production of yogurt. The gum can tolerate pH= 2, therefore, it is widely used in fermented foods (Wang *et al*., 2000).

This study aimed to investigate the effect of adding Quince seed mucilage (Qm) and Guar gum (Gg), as additives, to Doogh and determine their effects on the physicochemical (pH, acidity and viscosity) and sensory properties of Doogh in a period of 21 days (Amice *et al*., 1995; Baeza *et al*., 2003; Gallardo *et al*., 2007; Kiani *et al*., 2008; Lo *et al*., 1996; Tamime and Robinson, 2007; Vojnovic *et al*., 1993) by using Central Composite Design (CCD) and response surface method to design the experiments and find out the optimum conditions.

MATERIALS AND METHODS

Mucilage Extraction

The fresh *Hibiscus esculentus* fruits were collected and washed with water. Incisions were made with the fruits, then, left over night. The fruits were crushed and soaked in water for 5–6 hours, boiled for 30 minutes, and left to stand for 1 hour to allow complete release of the mucilage into the water. The mucilage was extracted using a multilayer muslin cloth bag to remove the marc from the solution. Acetone (three times the volume of filtrate) was added to precipitate the mucilage. The mucilage was separated, dried in an oven at 40°C, collected, ground, passed through a #80 sieve and stored in a desiccator at 30°C and 45% relative humidity till use (Nikoofar *et al*., 2013).

Preparation of Doogh

After preliminary experiments, the appropriate concentration of gum and mucilage needed for stabilization was determined. Subsequently, gum and mucilage were used in a range of 0-0.2 and 0-0.1% (w/w), respectively. For preparation of Doogh, firstly, Gg and Qm were gradually added to water (6 Kg) according to the experimental design (Table 2). Afterward, salt (0.70W/W %) was added and the gum–mucilage-salt mixture was heated at 80°C for 10 minutes, cooled down to ambient temperature and, subsequently, kept overnight at 5°C for complete hydration purposes. Next, yogurt was added to the mixture (4 Kg) and mixed at 3,000 rpm (SANYO, Japan) for 1 minute (Azarikia and Abbasi, 2010). Finally, it was poured in 250 mL glasses and was stored at refrigerator temperature for experiments.

pH and Acidity

The pH values were determined using a digital pH meter (pH 114, Snail Instruments), titratable acidity was measured by the titration method (ČSN 57 0529) using a standard solution of 0.25M sodium hydroxide (Gallardo, 2005).

Apparent Viscosity

The yoghurt samples were gently stirred 5 times in a clockwise direction with a plastic spoon prior to viscosity measurements. Apparent viscosity was measured at 7°C using a Brookfield digital Viscometer (Model DV-II, Canada) fitted with spindle 62. The Doogh sample was subjected to selected shear rates

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30 1/S for upward curve. Apparent viscosity was expressed as Pascal (mPa s).

Sensory Analysis

The sensory profile of the samples was evaluated after 1 day of cold stabilization by the panel of 15 familiar assessors (ISO 22935-1, ISO 8586-1) using a linear, graphical, unstructured, orientated scale (ISO 13299, ISO 6658, ISO 6564). The evaluated descriptors were selected according to the most frequent descriptors used for these kinds of food from the literature (Gallardo *et al*., 2007; Gallardo *et al*., 2005). All sensory properties (odour, color and overall acceptability) were scored between 1 to 5 scores. All samples were coded using three-digit, randomly generated numbers and served cooled at 4±2°C.

Central Composite Design

Central Composite Design (CCD) was used to design the experiment (Jahangiri *et al*., 2014). CCD determines an acceptable amount of information for testing well fitting and does not require an unusually large number of design points, thereby reduces the overall cost associated with the experiment. The response surface plots obtained through statistical process describes the design and the modeled CCD data. Response surface method graphically demonstrates the relationships between several parameters and the response (s). and is the way to obtain an accurate optimum (Jahangiri *et al*., 2014; Antelo *et al*. 2007; Coscolla *et al*., 2014; Rezazadeh Bari *et al*., 2010; Alizadeh *et al*., 2006). In order to obtain the optimum conditions, the effect of various parameters such as storage time of Doogh, percent of seed mucilage (Qm) and Guar gum (Gg) was taken account and the optimum conditions were chosen. Three variables, namely, the storage time of Doogh (F1), the percent of seed mucilage (Qm) (F2) and the percent of guar gum (Gg) (F3) were investigated at three levels with 8 cube point, 6 center points in cube and 6 axial points. Polynomial equations, response surface, and central plots for a particular response were created using Minitab 17. The performance of the system was defined by the following quadratic Equation (1):

$$Y = \beta_0 + \sum_{i=1}^{3} \beta_i x_i + \sum_{i=1}^{3} \sum_{j=i+1}^{3} \beta_{ij} x_i x_j + \sum_{i=1}^{3} \beta_{ii} x_{ii}^2 . \quad (1)$$

Where, Y is the response; β_0, β_i, β_{ii} and β_{ij} are constant coefficients and x_i the coded independent variables. The stepwise deletion of terms was applied to remove the statistically non-significant terms, so, simplifying the model. For each of the three studied variables, high (Coded value: +1) and low (Coded value: -1) set points were chosen to construct an orthogonal design as tabulated in Table 1. Also, Table 2 lists the coded values of designed experiments based on the CCD.

Experimental Design

The CCD was used for experimental analysis. The purposes of CCD were: (1) Investigation of the influence of storage time (day), Quince seed mucilage (Qm) and guar gum (Gg) as additives on the physicochemical (pH, acidity and viscosity) and sensory properties of Doogh ; (2) Recognition of the variables with highest effect on the odor, color, overall acceptability, pH, acidity and viscosity (note that, in the Doogh it is desirable that pH be the least, acidity and viscosity be the highest); and finally, (3) Displaying interactions between the variables.

RESULTS AND DISCUSSION

Study Factors Effect

In order to find out the significant factors that affect responses (odor, color, overall acceptability, pH, acidity and viscosity) and build a model to optimize the procedure, a

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Table 1. The variables and values used for Central Composite Design (CCD).

		Coded factor levels		
	Variable Name	-1 (Low)	0	1 (High)
F1	Time (Day)	1	11	21
F2	Qm (W/W %)	0	0.05	0.1
F3	Gg (W/W %)	0	0.1	0.2

Table 2. List of experiments in the CCD (coded values) and the responses of each run.

Run order	Factors			Responses					
				Physicochemical			Sensory		
	F1	F2	F3	pH	Acidity	Viscosity	Odour	Colour	OA[a]
1	1	1	-1	3.81	5.94	144.0	4.9	4.5	4.7
2	1	-1	1	3.81	6.57	643.1	4.6	4.6	4.7
3	-1	0	0	3.92	7.65	1225l.0	4.5	4.4	4.8
4	-1	-1	1	3.85	6.30	971.8	4.3	5.0	4.5
5	1	-1	-1	3.55	7.20	110.4	4.6	4.8	4.5
6	-1	1	-1	3.9	6.12	647.9	4.7	5.0	4.8
7	0	0	-1	3.82	7.11	307.1	4.9	5.0	4.7
8	0	-1	0	3.76	7.02	695.9	4.3	4.5	4.5
9	-1	1	1	3.88	5.94	1704	4.5	5.0	4.5
10	0	0	0	3.75	7.47	249.5	4.7	4.5	4.8
11	1	1	1	3.67	8.10	319.1	4.6	4.8	4.8
12	-1	-1	-1	3.84	5.31	255.9	5.0	5.0	5.0
13	0	0	0	3.79	7.47	664.7	4.0	4.6	4.5
14	0	0	1	3.78	7.47	643.1	4.6	4.7	4.8
15	0	1	0	3.76	7.02	633.5	4.4	4.5	4.8
16	1	0	0	3.62	7.74	304.7	4.3	5.0	4.5
17	0	0	0	3.77	7.29	439.1	4.6	4.8	4.5
18	0	0	0	3.77	6.93	247.1	4.7	5.0	4.8
19	0	0	0	3.74	6.66	218.4	4.9	5.0	4.7
20	0	0	0	3.82	8.91	657.5	4.3	4.5	4.5

[a] Overall Acceptability.

full quadratic model including all terms of Equation (1) (for all responses) was constructed at the first step. Then, in order to obtain a simple and yet a realistic model, the insignificant terms were eliminated from the model through 'backward elimination' procedure. By the elimination of nonessential terms of Equation (1) from the constructed model, calibration R^2, adjusted R^2 (R^2 adj), and R^2 of prediction were calculated for all the responses. The characteristics of the abstracted model, including R^2 values, standard error, and significant linear, quadratic, and interaction coefficients are shown in Table 3.

According to these results, the storage time of Doogh, Qm and Gg have affected the pH of Doogh and is an interaction between Qm (W/W%) and Gg (W/W%). However, in the case of acidity, the storage time of Doogh, Qm and Gg have affected the acidity of Doogh, but, there are not important interactions between storage time of the Doogh, added Qm, and Gg. The viscosity of Doogh is affected by storage time of Doogh, Qm, and Gg and there is an interaction between storage time of Doogh and Qm. The odor of Doogh samples is affected only by Gg concentration and other factors have not important effect on the odor. No factor has an important effect on the color of Doogh samples and overall acceptability of Doogh is affected by Gg concentration and time of storage.

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Table 3. Some characteristics of the constructed models for pH, acidity, viscosity, odor, color and overall acceptability.

Regression equation	Coefficient	Value
pH= *[b0+b1 time (day)+b2 Qm (W/W%)+b3 Gg (W/W%)+b4 Qm (W/W%)]×Gg (W/W%)*	b0	3.8010
	b1	-0.0093
R-sq *R*-sq (Adj) R-sq (Pred)	b2	1.495
75.48% 68.94% 34.19%	b3	0.608
	b4	-10.75
Acidity= *[b0+b1 time (day)+ b2 Qm (W/W %)+b3 Qm (W/W%)]×Qm (W/W%)*	b0	6.015
	b1	0.0423
R-sq *R*-sq (Adj) *R*-sq (Pred)	b2	38.2
45.53% 35.32% 11.14%	b3	-367
Viscosity= [*b0+b1 time (day)+b2 Qm (W/W%)+b3 Gg (W/W%)+b4 time (day)]×Qm (W/W%)*	b0	362
	b1	-15.2
R-sq *R*-sq (Adj) *R*-sq (Pred)	b2	5433
73.51% 66.45% 48.31%	b3	2816
	b4	-354
Odour= [b0+b1 Gg (W/W %)+b2 Gg (W/W %)×Gg (W/W %)]	b0	4.8200
R-sq *R*-sq(adj) *R*-sq(pred)	b1	- 5.42
34.47% 26.76% 14.33%	b2	19.60 Gg
Colour: There are no terms in the model		
Overall Acceptability= *[b0-b1 time (day)+b2 Gg (W/W %)+b3 time (day)]×Gg (W/W %)*	*b0*	- 0.01775
	b1	4.9053
S *R*-sq *R*-sq (Adj) *R*-sq (Pred)	*b2*	-1.913
0.131992 39.66% 28.35% 11.83%	*b3*	0.1375

Response Surface Method

To gain further insight about the influence of each variable, the three Dimensional (3D) plots for the predicted responses were formed based on the model function (Jahangiri *et al*., 2014; Antelo *et al*., 2007; Coscolla *et al*., 2014). Figures 1, 2, 3, and 4 show 3D plots of pH, acidity, viscosity and overall acceptability of Doogh *versus* pairs of variables while the other variable was kept in the center levels.

As shown in Figure 1, there is a non-linear relation between the pH and Qm-Gg but linear relations between the pH and Qm-time and pH and Gg-time are observed. According to Figure 2, there is a non-linear relation between the acidity of Doogh and Qm-time. Quince seed mucilage is a complex of a cellulosic fraction accompanying arabinose, a mixture of methylated and unmethylated aldobionic acids and xylose. Nikoofar *et al.* (2013), and coworkers in the similar work reported the effects of quince seed mucilage in amounts of 0.03, 0.05 and 0.1% (w/w) on the texture and physicochemical properties of semi fat set yoghurt. They analyzed acidity, syneresis, color, and the texture profile. According to their results, the acidity, color, and texture properties i.e. cohesiveness, adhesiveness, and stringiness, in semi fat yogurts containing quince seed mucilage had no significant difference with semi fat and full fat blank samples. The amounts of syneresis in samples containing quince seed

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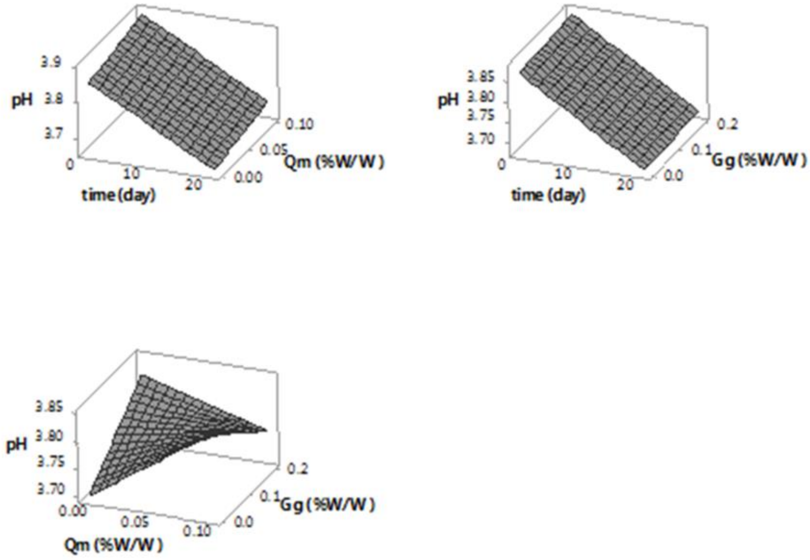

Figure 1. Response surfaces of pH of Doogh *versus* time-Qm, time-Gg and Gg-Qm.

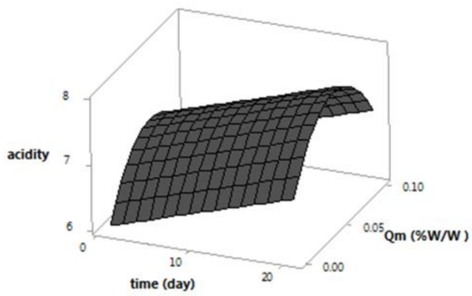

Figure 2. Response surfaces of acidity of Doogh *versus* time-Qm.

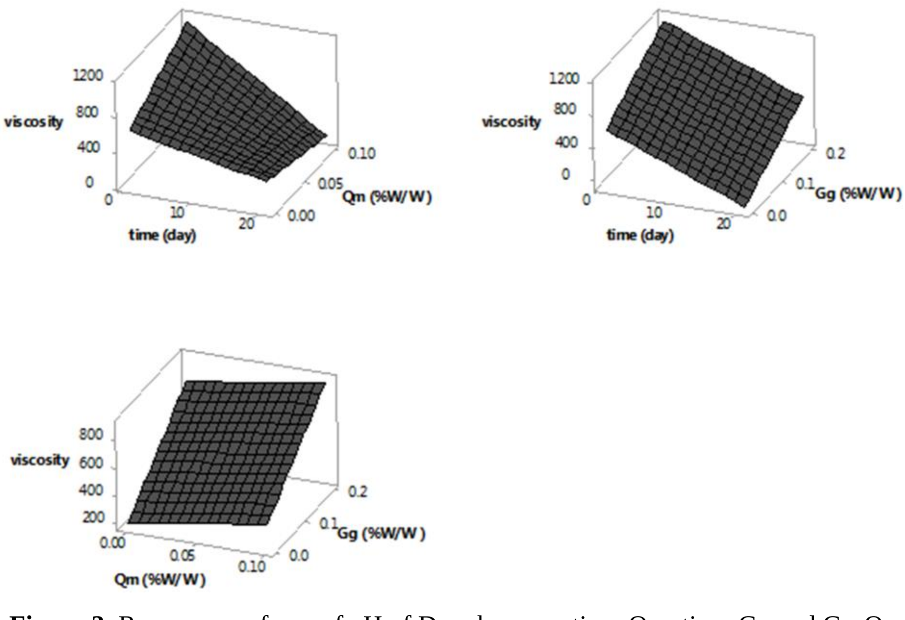

Figure 3. Response surfaces of pH of Doogh *versus* time-Qm, time-Gg and Gg-Qm.

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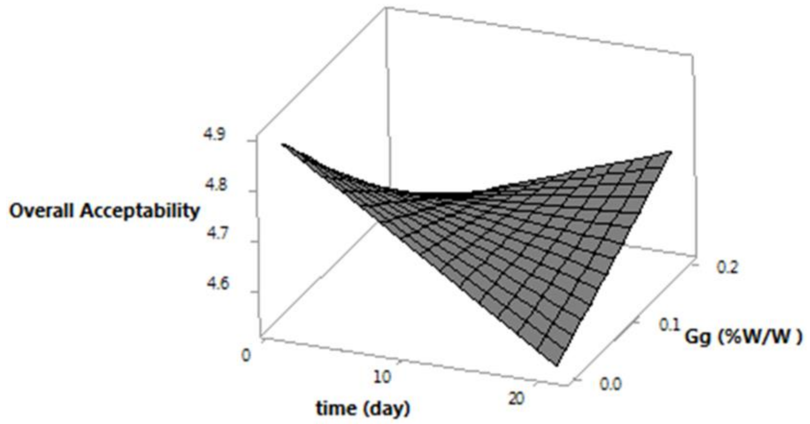

Figure 4. Response surfaces of overall acceptability of Doogh *versus* time-Gg.

hydrocolloid were decreased in comparison with semi fat blank samples. In texture properties, the amounts of hardness, gumminess, and chewiness in yogurts containing quince seed hydrocolloid were lower than semi fat and full fat blank samples (Nikoofar *et al*., 2013). According to their results, addition of quince seed mucilage to yoghurt did not change the color and acidity, adhesiveness, cohesiveness, and springiness.

It seems that negative charge of quince seed mucilage in interaction with a positive charge of casein micelles leads to decrease in the syneresis (increase the viscosity), but this hydrocolloid did not make a gel to increase hardness, gumminess and springiness in yogurts containing quince seed mucilage. Our results in the case of acidity, viscosity, and color is almost similar to the reported work, but there are some differences between our results and the reported work results that may be reffered to the difference of yogurt and Doogh matrix and type of milks. Figure 3 shows that there is a non-linear relation between the viscosity and Qm-time, but linear relations between the viscosity and Gg-time, viscosity and Qm-Gg. Figure 4 shows that there is a linear relation between the overall acceptability and Gg-time. In a similar work, Gorji *et al.* (2011) and coworkers (2011) studied the stabilising property of various concentrations of gum tragacanth in nonfat Doogh, by measuring phase separation, particle size, flow behavior and viscoelastic properties. According to their study, the addition of gum tragacanth improved stabilization of Doogh samples which was associated with an increase in apparent viscosity and storage modulus (Gorji *et al*., 2011). In our research, increasing Gg increases the viscosity of Doogh (viscosity increasing in the first days of storage time is more than last days).

Composite Desirability

Several approaches have been used to assess the multiobjective relation. One approach uses a constrained optimization procedure, while the second approach is used to solve the problem of multiple responses through the use of a desirability function that combines all the responses into one measurement, and its value changes between 0 and 1. The desirability functions, as an approach to use optimization procedure, have some advantages: (1) It is possible to compare responses with different scaling; (2) It is very fast and simple to transform different responses to one measurement; and (3) It is possible to use qualitative and quantitative responses. All desirability values for each response variable are computed. The overall Desirability function (D) is calculated by a geometric

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mean. Then, desirability values are combined into an overall desirability function. In the overall Desirability function (D), each response can be assigned an importance relative to the other responses (Alizadeh *et al*., 2006.).

Finally, it was necessary to find out the best condition of formulated Doogh by Gg and Qm, so, the obtained 3-dimentional plots were evaluated, and based on the results (pH, acidity, sensory properties and viscosity), the desirability functions for all responses and composite response were calculated by minitab-17 software. For desirability functions and composite desirability the following conditions were selected: pH at the minimum value while acidity, color, odor, overall acceptance and viscosity at the maximum values. Using the response surface plots, desirability functions and composite desirability of the optimum conditions were attained and are shown in Figure 5 and described in Table 4.

CONCLUSIONS

In this study, the new formulated Iranian

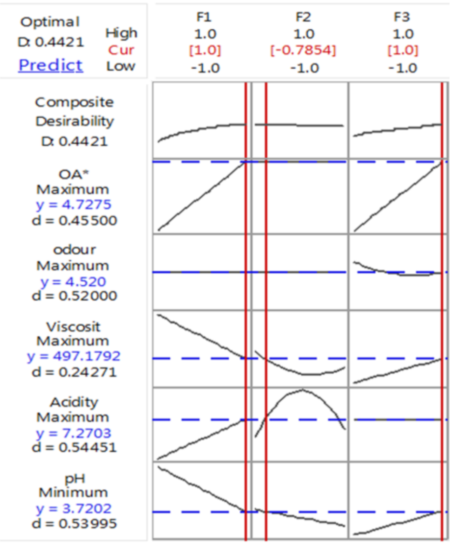

Figure 5. Desirability plot of responses desirability and composite desirability based on variables.

Table 4. Optimum conditions based on pH, acidity and viscosity desirability, composite desirability, and response surface modeling.

Desirabilty	Variable name		Optimum values	Selected values
pH	F1	Time (Day)	> 15	21
	F2	Qm (W/W %)	0-0.05	0
	F3	Gg (W/W %)	0-0.05	0
Acidity	F1	Time (Day)	> 15	21
	F2	Qm (W/W %)	0.05-0.054	0.052
	F3	Gg (W/W %)	Not effective	Not effective
Viscosity	F1	Time (day)	1-2	1
	F2	Qm (W/W %)	> 0.5	0.1
	F3	Gg (W/W %)	> 0.5	0.2
Composite desirabilty	F1	Time (Day)	14-21	21
	F2	Qm (W/W %)	0-0.05	0.02
	F3	Gg (W/W %)	0.15-0.2	0.2

Doogh based on guar gum and quince seed mucilage was tested and developed. The effects of time of storage, Quince seed mucilage (Qm) and Guar gum (Gg) on the physicochemical (pH, acidity and viscosity) and sensory properties of Doogh were studied. The stored Doogh at 4°C for 21 days was evaluated. Quince seed mucilage [0-0.1% (w/w)] and guar gum [0-0.2% (w/w)] were added to the Doogh. Central Composite Design (CCD) and response surface method were applied to design the experiments and find out the optimum conditions. The relations between storage time (day), Quince seed mucilage (Qm) and Guar gum (Gg) were evaluated. Results showed that all three factors (storage time, Gg%, and Qm%) affected the sensory properties and physicochemical properties of the new formulated Doogh. The optimum condition for Doogh based on sensory properties, pH, acidity and viscosity was obtained based on response surface analysis. According to the results, the lowest pH of the Doogh was obtained on day in 21st and 0% (w/w) of Qm and Gg.

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تاثیر موسیلاژ به‌دانه و صمغ گوار بر روی خواص فیزیکو شیمیایی و حسی دوغ

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چکیده

دوغ یکی از انواع نوشیدنی های ماستی در ایران است. این محصول یکی از نوشیدنی های لبنی می باشد و در ایران اهمیت فراوانی دارد. دوغ معمولا از اختلاط ماست با آب نوشیدنی، نمک و سبزیجات خوش عطر و طعم مانند آویشن ونعناع تهیه می شود. در این تحقیق اثر موسیلاژ بهدانه (از 0تا 0/1 درصد) و صمغ گوار (از 0 تا 0/2 درصد) و نیز زمان نگهداری دوغ (1 تا 21 روز) بر روی خواص فیزیکوشیمیایی و حسی ماست مورد بررسی قرار گرفته است. نمونه های دوغ تهیه شده در دمای 4 درجه سانتی گراد به مدت 21 روز نگهداری شده و بررسی شدند. موسیلاژ به دانه و صمغ گوار بر اساس طرح آماری مرکب مرکزی به نمونه های ماست اضافه شدند. از روش آماری سطح پاسخ برای بررسی اثر سه فاکتور درصد و موسیلاژ بهدانه و صمغ گوار و نیز زمان نگهداری بر روی خواص فیزیکوشیمیایی و حسی ماست و نیز برهمکنش های احتمالی بین فاکتور های موثر بر روی پاسخ ها استفاده شد. نتایج بدست آمده نشان داد که بر اساس پاسخ های بدست آمده شرایط بهینه متفاوتی برای فرمولاسیون ماست با استفاده از موسیلاژ بهدانه و صمغ گوار وجود خواهد داشت. مثلا اگر تنها اسیدیته محصول مد نظر باشد درصد موسیلاژ و صمغ صفر درصد مناسب می باشد در حالیکه از لحاظ کلی و با در نظر گرفتن تمامی شرایط درصد موسیلاژ 0/02 و درصد صمغ 0/2 بهترین حالت خواهد بود.

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