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Optimizing the formulation of gluten-free sponge cake based on rice flour containing tragacanth gum and date pomace powder using mixed statistical design

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ABSTRACT

Celiac disease is caused by the consumption of gluten in genetically predisposed individuals, and the only effective treatment is adherence to a lifelong gluten-free diet. This study aimed to optimize the formulation of a sponge cake based on rice flour with the addition of tragacanth gum and date pomace. The effects of two concentrations of tragacanth gum (0 to 1.5 percent) and date pomace powder in the range of 0 to 9 percent were investigated using a mixed statistical design on parameters such as moisture, specific volume, porosity, hardness, color indicators, and sensory characteristics of the rice cake. Results showed that all tested characteristics of the cake were influenced by the mixture components ($P<0.05$). Increasing tragacanth gum led to higher moisture content, porosity, L* and b* index, while hardness, a* index, and overall acceptance decreased. In a manner that maximizes moisture content, the sample containing 1.5% of tragacanth gum and no date pomace powder retains the highest amount of moisture. This sample has 49.93% more moisture than the sample containing 9% date pomace powder. Increasing date pomace powder decreased moisture, specific volume, L* and b* index, and overall acceptance, but increased hardness, porosity, and a* index. The optimal formulation included 0.9% tragacanth gum, 0.25% date pomace powder, and 98.85% other ingredients, achieving a desirability of 0.854.

1- Introduction

Cereals are one of the first foods known to mankind, and have always played a very important role in the economy and nutrition of the world's people, especially in developing countries, since ancient times [1]. Among the various products of the flour industry, cake stands out for its wide variety and popularity, especially among children and adolescents. This confectionery product, with its soft texture, is classified as a baked food and typically consists of flour, oil (excluding sponge cake), sugar, and eggs [2]. Flour serves as both a container for different cake components and a shaping agent, aiming to achieve a porous texture with small holes and a spongy consistency. While carbon dioxide, chemical leavening agents, or aeration from creaming oil, sugar, and eggs can create porosity in the cake, the gluten network is crucial for maintaining its spongy structure [3].

Unfortunately, some individuals cannot consume gluten-containing products due to celiac disease. This autoimmune disorder is triggered by the ingestion of gluten in genetically predisposed individuals, with gliadin in wheat, secalin in rye, avenin in oats, and hordein in barley being the main culprits. Upon consuming gluten, individuals with celiac disease experience a range of clinical symptoms stemming from impaired gluten digestion, ultimately leading to damage to the villi in the small intestine. Symptoms of celiac disease include osteoporosis, deficiencies in vitamin D and calcium due to intestinal malabsorption, neurological and mental health issues, infertility, sexual dysfunction, and digestive problems [4, 5, 6].

The only effective treatment for celiac disease is to adhere to a gluten-free diet throughout the patient's life. These patients must avoid consuming certain storage proteins (prolamins) found in wheat (gliadin), rye (squalin), and barley (hordein). Rice, scientifically known as *Oryza Sativa*, belongs to the Gramineae family and has properties such as the absence of gluten, low sodium levels, and high amounts of fast-digesting carbohydrates, making it suitable for celiac patients. Studies show that most commercial gluten-free breads have undesirable sensory properties due to the removal of gluten, resulting in bread texture that is rough, dense, low-volume, and has poor crust color, ultimately being unacceptable to the consumer and having a short shelf life [7, 8]. Gluten replacement is one of the challenging issues for the food industry because it is difficult to prepare gluten-free foods that have the desired nutritional and functional quality. Proteins, hydrocolloids, emulsifiers, or a combination of these materials are used to improve the physical properties and nutritional content of gluten-free products [9].

Tragacanth gum, as one of the plant exudates, is obtained from perennial species of Astragalus and shrub-like species [10, 11] with woody stems that grow in Iran, Syria, Turkey, and some other parts of the Asian continent [12]. Chemically, tragacanth is a heterogeneous and highly branched hydrophilic carbohydrate consisting of two main components, tragacanthic acid or basurin and tragacanthine [13]. Tragacanth has been listed in GRAS as a quality hydrocolloid by the US Food and Drug Administration [14]. This gum has been widely used in the food industry, especially in baking products, due to its emulsifying, stabilizing, and thickening properties [15]. Researchers who have used gums in the formulation of various grain-based products include Sheikhol-Islami et al. (2017), Billiadris et al. (1997), and Kumari et al. (2011) [16. 17. 18]. The date palm is one of the oldest fruit trees known to man. Most species of the genus Follix are grown as ornamental plants indoors or outdoors, and the only species whose fruit is edible is the common date palm. Iraq has always been the largest producer of dates in the world, and Basra is world-renowned for its high-quality date varieties [19], which can be enriched by adding them to various food products due to the presence of salts, dietary fibers, and various vitamins in dates. Various studies have been conducted on the use of date derivatives, including date fruit powder, sugar, and date syrup, in the preparation of bakery products [20, 21, 22]. The aim of this study, given the limited research on the use of tragacanth gum and date pomace powder, waste products of organic sugar factories, in the production of gluten-free sponge cake based on rice flour, was to improve its properties and optimize the sponge cake formulation.

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2- Materials and Methods

2 -1- Materials

In this study, tragacanth gum from Pars Analysis Company, date pulp powder from Shahd Babars Company, and other required materials from stores in Tabriz were used to prepare sponge cake. The equipment used in this study included a laboratory sieve, laboratory oven (Memert, Germany), digital scale (Gec Avery, made in England), electric dough mixer (Phillips, China), bakery oven (Mashhad Baking Industries, Iran), and texture tester (Lefra, USA).

2- 2- Methods

2- 2- 1- Preparation of Dough and Baking Sponge Cake

The cake dough was prepared using the sugar-dough method. The different formulations used in this study are outlined in Table 1. After preparing the dough, greaseproof paper was placed inside the cake molds, and 50 grams of the prepared mixture was poured into each one. The molds with the cake dough were then placed in the oven at a temperature of 180-190 °C for 20-25 minutes. Once baked, the cakes were removed from the oven and allowed to cool. To expedite the cooling process, the cake molds were turned upside down so that the cakes were exposed to air and cooled more quickly. This method helped the cakes to come out of the molds easily and prevented sweating. After the production stages were completed, the samples were stored in polyethylene bags at ambient temperature (25 °C) until the testing stages were conducted.

Table 1- Mixture composition in the soup formulated with Tragacanth gum (x_1), Date pulp power (x_2) and Other compound (x_3) in a three component constrained D-optimal mixture design.

Number of sample	Tragacanth gum (x_1): (%)	Date pulp power (x_2): (%)	Other compound (x_3): (%)
1	1.5	9	89.5
2	1.5	0	98.5
3	0.5	9	90.5
4	0.5	6	93.5
5	0	0	100
6	0	9	91
7	1	3	96
8	0	6	94
9	1.5	3	95.5
10	0	6	94

2- 2- 2 -Determination of moisture content

The AACC method number 16-44 was used to measure the moisture content of the samples [23].

2- 2- 3 -Measurement of specific volume

The volume of the resulting samples was measured using the rapeseed displacement method [24].

2- 2- 4 -Evaluation of porosity

To evaluate the porosity of the samples, an image processing method was used by taking pictures with a digital camera with a resolution of 12 megapixels and analyzing with Image J software [25].

2- 2- 5- Texture hardness test

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The internal texture hardness of the produced samples was measured and evaluated on the first day after baking by a texture tester. The maximum force required to penetrate a cylindrical prong with a diameter of 1.38 mm at a speed of 1 mm/s into the center of the cake core slices was calculated as the hardness index. The recovery time was 1.5 seconds, and the thickness of the cake core slices was 2 × 2 × 2 cm^3 and the compression rate was determined to be 50% of the initial cake height. The starting point and target point were 5 g and 10 mm, respectively. This test was performed at a temperature of 25 °C [26].

2- 2-6- Evaluation of Color Indices

To analyze the color of the samples, computer image processing was utilized. In this method, the surface of the samples was photographed using a digital camera. The samples were placed inside a chamber with a black background, and a low-energy fluorescent lamp was used to illuminate the space. The angle between the camera lens and the axis of the light source was approximately 45 degrees to ensure that the light reflected to the camera came from the samples rather than the light source. The distance between the samples and the camera was set at 30 cm . After transferring the images to the computer, the color indices (L*, a*, and b*) were determined using the Photoshop version (CC) program. By calibrating the values of these parameters using color cards, the actual levels of these parameters were determined . The L* index represents the brightness of the sample, with a range from zero (pure black) to 100 (pure white). The a* index indicates the degree of closeness of the sample color to green and red colors, with a range from -120 (pure green) to +120 (pure red). Finally, the b* index shows the degree of closeness of the sample color to blue and yellow colors, with a range from -120 (pure blue) to +120 (pure yellow) [25].

2- 2- 7- Sensory evaluation of samples

The sensory properties of the production samples were evaluated through a taste test. Nine trained evaluators evaluated the characteristics of the production samples to determine the overall acceptance using equation (1) and applying evaluation coefficients of 1, 3, 4, and 3 for color, texture, flavor, and aroma, respectively, on a scale of 1-5 (1 being the lowest and 5 being the highest score) [27].

Eq (1) $$Q = \frac{\sum(P \times G)}{\sum P}$$

Q = overall acceptance (number of quality samples produced), P = trait ranking coefficient, and G = trait evaluation coefficient.

2- 3- Statistical analysis

In this study, in order to optimize the formulation of gluten-free sponge cake based on rice, D-optimal mixture design and Design Expert software version 6.0.2 were used, which three components of the formula included different percentages of tragacanth gum (x1), date pulp powder (x2) and other ingredients (x3). To compare the data with each other, a completely randomized design of SAS 1.9 software and Duncan's multiple range test at the probability level ($p<0.05$) were used.

3- Results and discussion

3- 1- Effect of formulation type on moisture content

The results of Duncan's test and Figure 1 showed that the sample containing 1.5% tragacanth gum and no date pulp powder had the highest moisture content. This sample had 49.93% more moisture than the sample containing 9% date pulp powder. It is evident that moisture content increased with the higher tragacanth gum content in the formulation. Hydrocolloids, because of their hydrophilic nature, contain hydroxyl groups in their structure. This characteristic allows them to interact more with water through hydrogen bonds, leading to an increase in water and moisture absorption [26, 28]. Moayedi et al. (2014) demonstrated in their research that adding tragacanth to a voluminous bread formula increased its moisture content, with the moisture content increasing as the tragacanth concentration increased [15]. Sheikholeslami et al. (2020) also found that hydrophilic hydrocolloids, such as gums, interact with water due to their hydrophilic nature, reducing water diffusion and increasing water absorption in the dough, thus maintaining moisture content in the final product during baking and storage [29]. Arabshirazi et al. (2012), Ashwini et al. (2009), and Seyhun et al. (2003) confirmed in

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their studies that emulsifiers can increase the moisture content of the final product. However, an increase in date pulp, containing compounds like higher fat content, led to a decrease in moisture content of the samples [30, 31, 32]. These results align with Obiegbuna et al. (2013) and Peter Ikechukwu et al. (2017) [20, 21]. Model 1 in Table 3 showed that the amount of tragacanth gum had a significant impact on the moisture content of the samples, with the linear model being the most suitable for analyzing the results obtained from the moisture content of the samples.

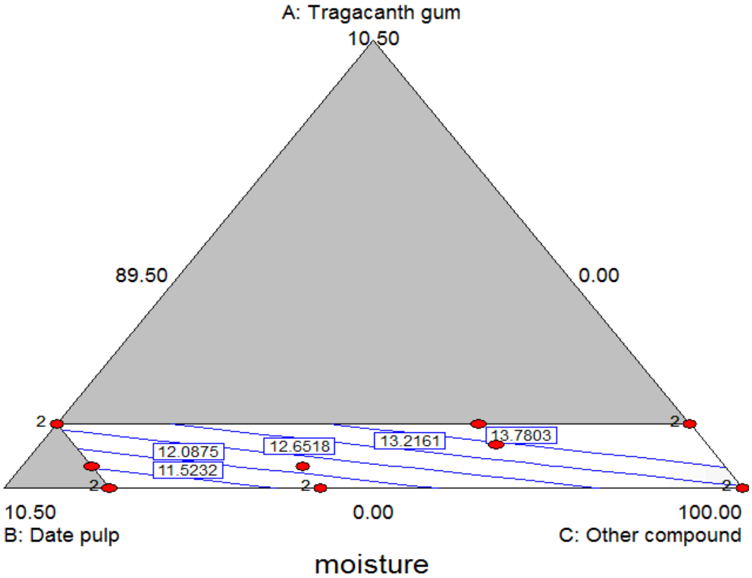

Figure 1- Contour diagram of the moisture content of the produced cakes under the influence of different formulations

Table 2-Experimental results of the assessed properties

Number of sample	Moisture (%)	Specific volume (ml/g)	Hardness (g)	Porosity(%)	L*	a*	b*	Total acceptance
1	12.90^{d}	1.22^{e}	1500^{e}	23.14^{de}	72.49^{f}	-10.22^{h}	52.93^{h}	3.75^{d}
2	15.45^{a}	1.46^{b}	735^{j}	33.54^{bc}	80^{a}	-10.89^{i}	76.12^{a}	4.32^{b}
3	11.80^{h}	1.16^{g}	1705^{b}	32.2^{bc}	75.9^{d}	-9.9^{g}	68.29^{c}	3.78^{d}
4	12.60^{e}	1.25^{d}	1320^{f}	34.69^{b}	75.9^{d}	-5.81^{bc}	63.27^{f}	3.9^{cd}
5	13.10^{c}	1.31^{b}	1132^{g}	23.07^{ef}	78.58^{b}	-9.15^{f}	70.17^{b}	5^{a}
6	10.66^{i}	1.14^{h}	1898^{a}	27.07^{cd}	72.05^{g}	-7.67^{e}	63.59^{f}	3.8^{cd}
7	12.39^{f}	1.24^{d}	1027^{i}	40.02^{a}	78.15^{c}	-7.49^{d}	65.47^{e}	4.33^{b}
8	12.00^{g}	1.19^{f}	1608^{c}	21.74^{f}	71^{h}	-5.8^{b}	66^{d}	4^{c}
9	14.00^{b}	1.27^{c}	1120^{h}	32.01^{bc}	73.14^{e}	-5.84^{c}	60.45^{g}	3.99^{c}
10	12.10^{g}	1.20^{f}	1515^{d}	21.74^{f}	70.96^{h}	-3.65^{a}	66.09^{d}	4^{c}

Numbers with different letters in each column imply significant differences in the 5% level of probability.

3- 2- Effect of variables on specific volume

Cake volume indicates the amount of air, water vapor, and carbon dioxide produced, as well as the rate of change during baking in the cake dough. In other words, cake volume depends on the protein network's ability to retain carbon dioxide gas produced during fermentation [33]. Increasing the amount of tragacanth in the cake formulation resulted in an increase in specific volume of the samples (Figure and Table 2). Researchers suggest that the increase in specific volume when using gums in baked products is due to the gums' effect on enhancing the

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consistency and strength of the dough's internal environment, increasing elasticity, which prevents gas cells from connecting and growing well [34]. It has also been noted that gums have emulsifying properties and form a surface layer around gas bubbles, aiding in gas retention in the dough. Sheikholeslami et al. (2017) demonstrated in their study that increasing the concentration of tragacanth and balango gums in frozen half-baked barbarian bread formulations initially increased and then decreased specific volume. They attributed the decrease in bread volume to the gums' lack of expansion during baking, disruption in the fermentation stage caused by excessive water absorption by the gums, and the fact that tragacanth contains simple sugars that can enhance yeast activity, leading to increased bread volume [17]. Results showed that increasing the amount of date pulp powder in the cake formulations decreased the specific volume of the samples. The increase in sugar and fat content in the dough due to the addition of date kernel powder can raise the gelatinization temperature of starch and create a denser texture in the product, necessitating further research [35]. The type and amount of sugar and fat consumed are crucial in this regard. Karambakhsh et al. (2024) demonstrated that increasing the amount of date pulp powder led to higher density and early release of air bubbles and gases before the dough fully sets, resulting in decreased sponge cake volume [36]. Wang et al. (2012) found that adding fiber to bread significantly reduced bread volume [37]. The interaction parameter of the amount of tragacanth gum and date pulp powder had the most significant effect on the specific volume of the samples, as depicted in model number 2 of Table 3.

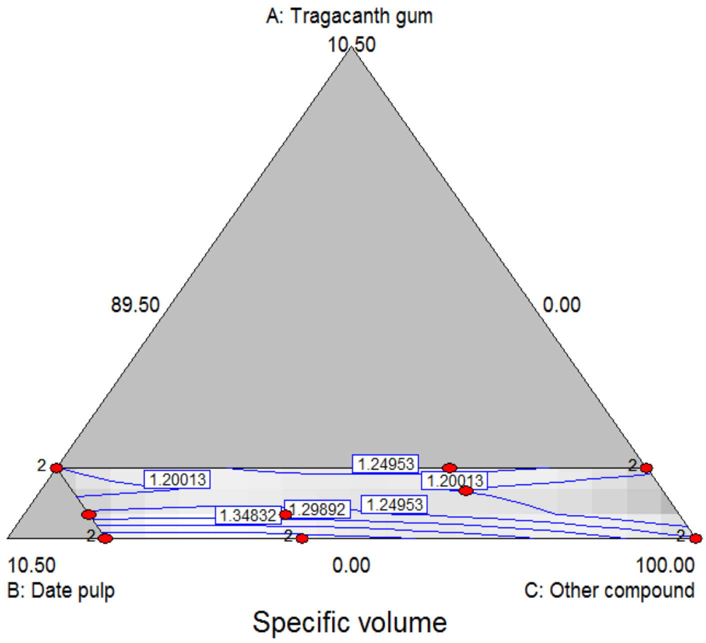

Figure 2- Contour diagram of the specific volume of the produced cakes under the influence of different formulations

3-3- Effect of formulation type on hardness

The hardening, loss of crispness, and brittleness of products like bread and cake are generally related to staleness [38]. The stagnation or hardening of the texture of these products during storage is a complex process that involves several factors. These factors include recrystallization of gelatinized starch, particularly short-chain amylopectins, retrogradation of amylose, binding of amylose and amylopectin to each other, moisture migration after starch crystallization, absorption of moisture removed from starch by gluten, and reduction of moisture content or moisture distribution between amorphous and crystalline regions[39, 40]. The results indicated that adding tragacanth gum and date pulp powder to the cake decreased its hardness, with a greater decrease when tragacanth gum

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was used. Researchers have suggested that hydrocolloids reduce the hardness of bread crumb through two different phenomena. The first is the reduction of starch granule swelling and the washing and removal of amylose, while the second is the weakening effect of gums on the starch structure by preventing the joining of amylose chains. The importance of these effects depends on the type of hydrocolloid [22]. The decrease in bread crumb hardness due to hydrocolloid addition may also be due to increased moisture content in the samples, as there is an inverse relationship between bread crumb hardness and moisture content [41, 42]. These findings align with previous studies by Ashwini et al. (2009) and Kumari et al. (2011) [18, 31]. The decrease in hardness of the samples produced with an increasing percentage of date pulp powder may be attributed to potential interactions of hydrocolloids with flour proteins, preventing the formation of a strong internal network [43]. The predicted model for the hardness data under the influence of formulation is provided in Table 3.

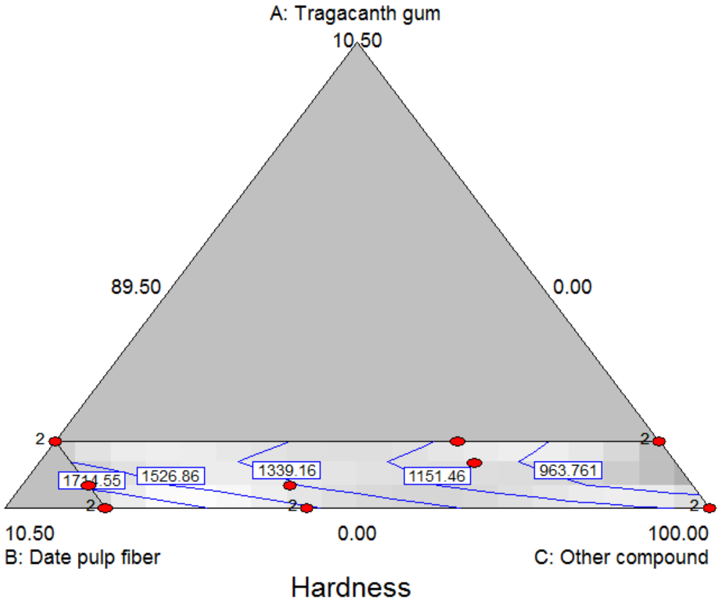

Figure 3- Contour diagram of the hardness of the produced cakes under the influence of different formulations

Table 3- Designed equation models for dependent variable

Number	**Dependent variable**	**Equation**	**R^2**	**R^2-adj**	**cv**
1	Moisture (%)	$y= + 26.33\ X_1+10.57\ X_2+ 13.16\ X_3$	0.901	0.88	3.86
2	Specific volume (ml/g)	$y= +19.48\ X_1+1.44\ X_2+1.25\ X_3 +23.05X_1X_2 – 21.55X_1X_3 +0.\ 28\ X_2X_3$	0.938	0.900	2.54
3	Hardness (g)	$y= +26715\ X_1+2135\ X_2+1131\ X_3 – 33808X_1X_2 – 33019X_1X_3 – 645X_2X_3+ 9258X_1X_2X_3$	0.995	0.991	2.63
4	Porosity (%)	$y= –1573X_1+28.55\ X_2+22.73\ X_3 + 1855\ X_1X_2 +1952X_1X_3 – 7.00\ X_2X_3$	0.760	0.615	12.17
5	L*	$y= –737X_1+73.89\ X_2+78.64\ X_3 + 933\ X_1X_2 +961X_1X_3 – 20.66\ X_2X_3$	0.990	0.984	0.57

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6	a*	$y= +208.86X_1 – 11.12 X_2 – 9.27 X_3 – 248.28 X_1X_2 – 266.16X_1X_3 +24.45 X_2X_3$	0.946	0.913	–8.18
7	b*	$y= –604.68X_1+73.89 X_2+78.64 X_3 + 933 X_1X_2 +961X_1X_3 – 20.66 X_2X_3$	0.911	0.855	4.09
8	Total acceptance	$y= –9.20X_1+3.74 X_2+5.00 X_3 + 15.18 X_1X_2 +11.32X_1X_3 – 1.02 X_2X_3$	0.955	0.928	2.78

3- 4- Effect of independent variables on porosity

The results indicated that the highest porosity was associated with the sample containing 1% tragacanth gum and 3% date pulp powder, while the lowest was seen in the sample without tragacanth gum and date pulp powder, showing no statistically significant difference compared to the sample without tragacanth and 6% date pulp powder (Table 2 and Figure 4). Hydrocolloids play a crucial role in enhancing dough consistency, forming a temporary gel network, and increasing the stiffness of the walls surrounding gas-containing cells in bread. This leads to better retention of carbon dioxide gas and water vapor produced in the dough, ultimately resulting in increased bread porosity. Some gums also exhibit emulsifying properties, creating a surface layer around gas bubbles in the dough that aids in gas retention [44, 45]. Conversely, decreased porosity can be attributed to the formation of a stronger network that leads to excessive compaction of the bread crumb, hindering gas cell growth and resulting in a nearly bubble-free texture, ultimately reducing bread porosity [46]. In a study by Avazsufian et al. (2014) utilizing sweet almond meal and xanthan gum in gluten-free cake, sweet almond meal significantly boosted the porosity of the texture in all cake samples compared to the control sample, attributed to a decrease in cell size and an increase in cell number in the product texture [9]. Similar findings have been reported regarding the impact of various gums on the porosity of produced samples [47]. The equation derived from the quadratic model data for porosity is outlined in Table 3, highlighting the significant impact of the interaction parameter between the amount of tragacanth gum and other ingredients on porosity.

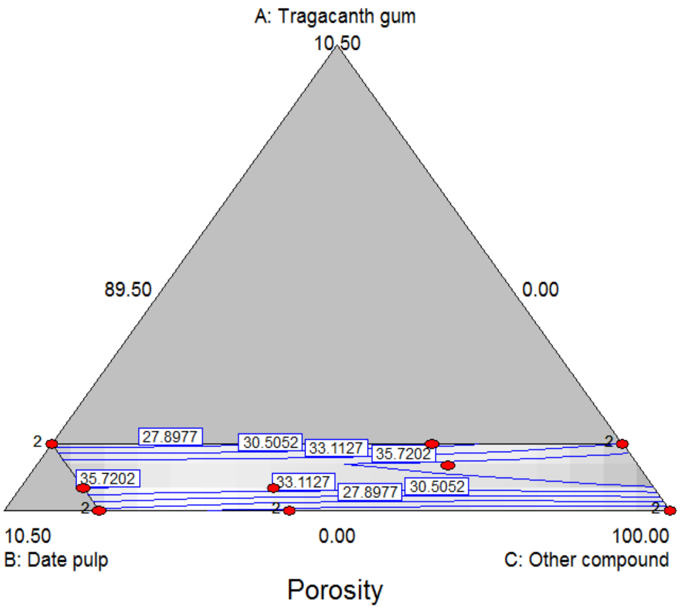

Figure 4- Contour diagram of the porosity of the produced cakes under the influence of different formulations

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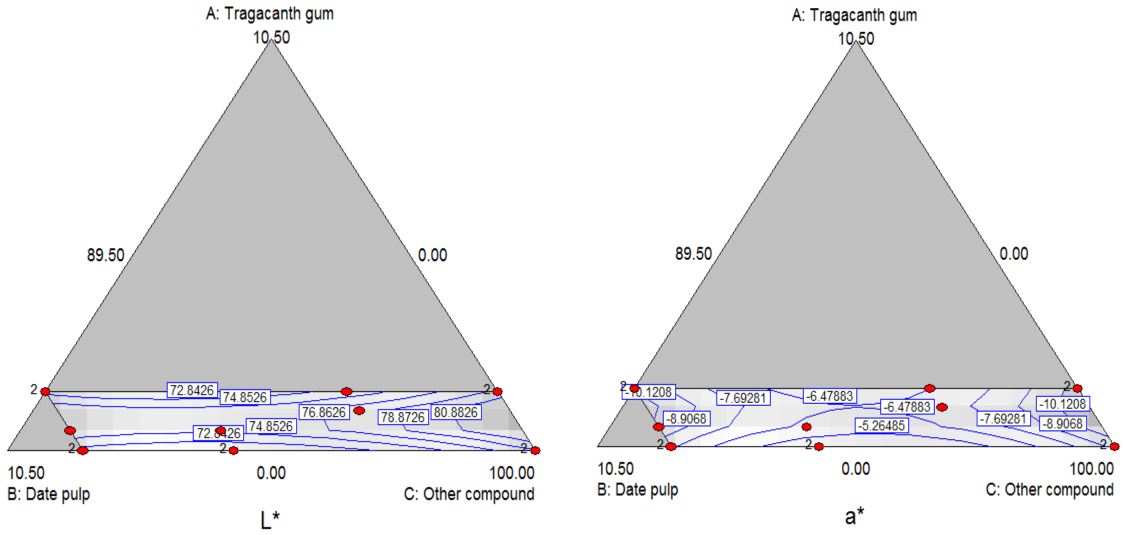
3- 5- Effect of formulation type on color indices

One of the qualitative characteristics of food products is their color, which plays a crucial role in the acceptance of food products today. If a food product lacks the appropriate color, which is one of the appearance characteristics, it will experience a significant decrease in its market value. Other qualitative characteristics such as aroma, taste, texture, etc. are parameters that are evaluated after consuming the food product, and sometimes after purchasing and consuming it once. Color is a key factor in attracting attention and selecting a food product, and its presence is instrumental in quickly determining the final acceptance of any food product, as color enhances the appeal of the food product [48]. The results (Table 2) indicated that the highest L* and b* indices were observed in sample number 2, which utilized 1.5% tragacanth gum. Conversely, the a* index was highest in the sample containing 6% date pulp powder and no tragacanth gum. Essentially, the use of different ingredients, particularly date pulp powder, with its dark color, resulted in a decrease in the L* and b* indices, aligning with the findings of Majzoubi et al. (2015) and Borchan et al. (2011) [35, 49], while the a* index, or redness, increased (Figure 5). In this context, Purlis and Salvadori (2009) suggested that changes in the texture of the surface likely contribute to the brightness of baked goods, with regular and smooth surfaces reflecting more light than wrinkled surfaces [50]. Additionally, Whitehurst (2004) mentioned that the use of emulsifiers facilitates even distribution of air bubbles throughout the dough, releasing air evenly from these bubbles during baking [51]. The models pertaining to the color indices of the produced samples are outlined in Table 3. Based on this table, it can be concluded that the generated models exhibit higher accuracy in predicting the data obtained from L*.



a) b)

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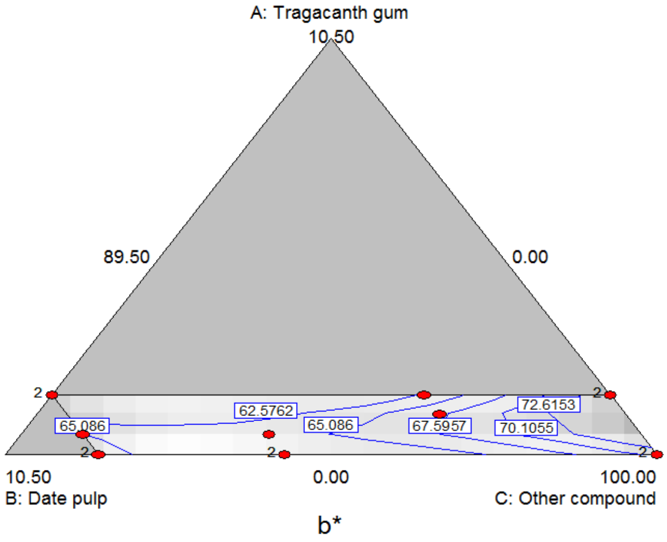

c)

Figure 5- Contour diagram a) L* index, b) a* and c) b* index of the produced cakes under the influence of different formulations

3- 6- Effect of formulation type on overall acceptance

Table 2 showed that the maximum and minimum overall acceptance from the evaluators' perspective belonged to the sample without additives and containing 1.5% tragacanth gum and 9% date pomace powder, respectively, which did not differ significantly from the sample containing 0.5% tragacanth gum and 9% date pomace powder. In other words, adding tragacanth gum and date pomace powder reduced the overall acceptance of the samples to some extent (Figure 6), which was also related to the evaluators' perception of the cake. On the other hand, the results indicated that the quadratic polynomial model was the best model for fitting the data obtained from overall acceptance and that the interaction effect of the amount of tragacanth gum and date pomace powder had the greatest effect on this characteristic, and the equation related to this characteristic is also given in Table 3. The results of this section were consistent with the results of some researchers [20, 35], but contradicted the results of Sheikholeslami et al. (2017) and Mohammadi et al. (2014), who stated that the use of gums leads to an increase in sensory scores [16, 47].

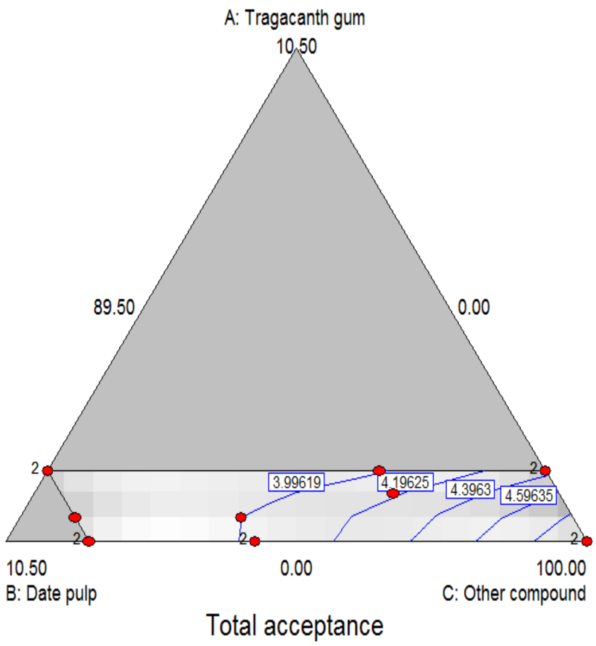

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Figure 6- Contour diagram of the overall acceptance of the produced cakes under the influence of different formulations

3- 7- Optimizing the formulation of gluten-free sponge cake based on rice flour

In this study, in order to optimize the formulation of gluten-free rice cake, based on the review of sources and evaluation of samples, the optimal region and the results obtained from it were defined based on the limits determined for the independent variables. Given that at the optimal point, the amount of tragacanth gum, date pulp and other materials was 0.9, 0.25 and 98.85 percent, respectively, the desirability was 0.854. In order to ensure the accuracy of the results, the predicted formula obtained from the optimal region along with two formulas from the non-optimal region was reproduced and its properties were examined, and in this way the optimal formula was approved.

Table 4- Optimized conditions.

Tragacanth gum (%)	Fibre (%)	Other compound (%)	Moisture (%)	Specific volume (ml/g)	Hardness (g)	Porosity (%)	L*	a*	b*	Total acceptance
0.9	0.25	98.85	14.23	1.38	761.85	38.70	83.44	-10.93	76.30	4.62

4- General conclusion

This study, which was conducted with the aim of optimizing the formulation of gluten-free sponge cake based on rice flour containing tragacanth gum and date pulp powder, showed that increasing the amount of tragacanth gum in the formulation increases the moisture content, porosity, L* and b* indices, but decreases the hardness, a* index, and overall acceptance. By increasing the amount of date pulp in the formulation, the moisture content, specific volume, L* and b* indices, and overall acceptance decreased, but the hardness, porosity, and a* index increased. Finally, according to the results of this study, it can be stated that for the production of gluten-free cake based on rice flour containing tragacanth gum and date pulp powder, the amount of tragacanth gum and date pulp powder in the formulation of the produced cakes should be 0.9 and 0.25 percent, respectively, in order to produce the best cake in terms of quality.

5-Reference

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مقاله علمی_پژوهشی

بهینه‌یابی فرمولاسیون کیک اسفنجی فاقد گلوتن بر پایه آرد برنج حاوی صمغ کتیرا و پودر تفاله خرما با استفاده از طرح آماری مخلوط

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چکیده

سلیاک یک بیماری ایجاد شده توسط مصرف گلوتن در افراد مستعد از لحاظ ژنتیکی می‌باشد که تنها درمان موثر برای این بیماری پایبندی به یک رژیم غذایی فاقد گلوتن در سراسر طول عمر بیمار می‌باشد. بنابراین هدف از این مطالعه بهینه‌یابی فرمولاسیون کیک اسفنجی بر پایه آرد برنج با افزودن صمغ کتیرا و تفاله خرما بود. اثرات دو غلظت صمغ کتیرا (۰ تا ۱/۵ درصد) و پودر تفاله خرما در محدوده‌ی ۰ تا ۹ درصد با کمک طرح آماری مخلوط بر پارامترهای رطوبت، حجم مخصوص، تخلخل، سختی، شاخص‌های رنگی و خصوصیات حسی کیک برنجی بررسی گردید. بر اساس نتایج این پژوهش کلیه ویژگی‌های مورد آزمایش کیک تهیه شده تحت تأثیر اجزای مخلوط بود (P<۰/۰۵). افزایش میزان صمغ کتیرا در فرمولاسیون منجر به افزایش مقدار رطوبت، تخلخل، شاخص L^* و b^* شد. به‌گونه‌ای که بیشینه میزان رطوبت متعلق به نمونه حاوی ۱/۵ درصد صمغ کتیرا و فاقد پودر تفاله خرما بود که این نمونه دارای ٤۹/۹۳ درصد رطوبت بیشتری از نمونه‌ی حاوی ۹ درصد پودر تفاله خرما داشت. در حالی‌که میزان سختی، شاخص a^* و پذیرش کلی کاهش یافت. با افزایش پودر تفاله خرما در فرمولاسیون میزان رطوبت، حجم مخصوص، شاخص L^* و b^* و پذیرش کلی کاهش ولی میزان سختی، تخلخل و شاخص a^* افزایش یافت. میزان صمغ کتیرا، پودر تفاله خرما و سایر مواد در فرمولاسیون بهینه به ترتیب برابر ۰/۹، ۰/۲۵ و ۹۸/۸۵ درصد بود که در این نقطه مطلوبیت ۰/۸٥٤ حاصل گردید.