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Optimization of Gluten- Free Semolina Dessert (Revani) Formulation Including Different Flours: Response Surface Methodology

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Highlights:
- Alternative dessert
- Celiac syndrome
- Different flour types
- Optimization

Keywords:
- Semolina dessert gluten-free
- Celiac
- Response surface methodology

ABSTRACT:

Celiac syndrome occurs as a result of the deterioration of the natural structure of the intestine due to the consumption of foods containing gluten. Since semolina dessert contains gluten protein, it cannot be consumed by celiac patients. The production of alternative gluten-free products shows that these products are of great importance for this patient group. In this study, gluten-free semolina dessert formulations using rice flour (RF) and buckwheat flour (BWF) and chestnut flour (CF) were optimized using Response Surface Methodology (RSM). Potato Starch (PS) was added to the samples containing BWF and CF. It was determined that the addition of PS increased the processibility of the flour of the semolina dessert prepared with chestnut flour and the consumability of the semolina dessert prepared with buckwheat flour. It was determined that the use of different grades of flour, potato starch/corn semolina mixture, egg white and yolk powder and drinking water increased the volume, symmetry index, chewiness and texture values of the sample ($p<0.05$). When all components are taken into account, in BWF formulation (62.5/37.5) % flour/corn semolina mixture, 75.85% drinking water 14.73 egg white and yolk powder (same amount) and (50/50) flour/corn semolina mixture in RF formulation, % 81.46, drinking water 14.91% yolk and egg white powder (same amount), in CF formulation (50/50) flour/corn semolina mixture, 60.30% water when drinking, 14.95% egg white and yolk It was possible to produce gluten-free semolina, which is the closest dessert to the control sample semolina dessert by using powdered semolina. As a result of the sensory scores of the prepared revanis (with different formulations), the control sample, rice, chestnut and buckwheat semolina dessert got the highest score, respectively.

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This study was summarized from the Master Thesis of the author named "A study on gluten-free dessert (revani) production Abstract part of this thesis was presented as a poster presentation in 2nd Congress on Food Structure & Design- Akdeniz University, Turkey (26-28 October 2016 Porto Bello Hotel, Antalya- www.fsd2016.org)
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INTRODUCTION

Celiac (celiac/coeliac/sprue) is a disease characterized by an immune system-related intestinal problem resulting from the interaction of genetic factors (Anonymous, 2014). When people with celiac disease consume foods that contain gluten, their immune system is stimulated, leading to inflammation in the inner surface of the intestines. As a result, the consumption of gluten-containing foods by individuals with celiac disease reduces the absorption of some nutrients and causes deficiencies of essential substances for the body (Gallagher et al., 2004). Some cases are asymptomatic and some may present with a wide variety of clinical symptoms. In such cases, early diagnosis is important. Otherwise, it may result in death. The incidence of celiac disease varies between 1 percent and 3 per thousand. In Turkey, it is estimated that there are between 250 thousand and 750 thousand celiac patients. However, only 10 percent of them are diagnosed, which means that an estimated number of 25 thousand to 75 thousand patients are expected to be undiagnosed (Aydoğdu et al., 2005). When this is the case, the product range of celiac patients should be expanded significantly. The majority of studies conducted so far have focused on bread and cake products. This highlights the significance of the work we aim to undertake, as it will provide a fresh perspective on sweet products that can be safely consumed by individuals with celiac disease. Gluten is a protein found in grains, especially wheat. In addition, celiac patients feel discomfort when cereal products such as rye, barley and oats are consumed (İşleroğlu et al., 2008). For this, alternative product groups that do not contain gluten and also have nutritional and functional properties should be preferred (Rai et al., 2018). According to Lai (2001), rice protein does not contain wheat protein, which is responsible for providing dough structure. On the other hand, buckwheat protein offers high nutritional value and a superior amino acid profile compared to bread wheat proteins, making it a favorable choice for incorporating into gluten-free food products. Chestnut flour contains essential amino acids and high-quality protein (4-7%). In addition, it contains high sugar (20-32%), starch (50-60%), dietary fiber (4-10%) and low fat (2-4%). In this context, chestnut flour can be used in products prepared from gluten-free flour due to its rich nutritional value and health benefits (Yıldız and Yalçın, 2013). Semolina dessert, also known as revani, is a dessert that consistently claims its place as the highlight of our table during every meal. Gluten-free formulations of revani were developed using the Response Surface Method, incorporating various flour sources (rice flour, buckwheat flour, chestnut flour) suitable for consumption by individuals with celiac disease. The study aimed to investigate the effects of these ingredients on the characteristics of revani.

MATERIALS AND METHODS

In this study, special-purpose wheat flour (Söke Flour, Aydın) with 9.45% protein and 0.47% ash content were used for the production of control revani dessert, and three different flours were used for gluten-free revani dessert. These; Buckwheat flour with 10.32% protein, 1.93% ash (Fitmek, İzmir) and chestnut flour with 5.45% protein and 2.1% ash (Kafkas, Pasta Confectionery Industry and Trade Inc., Bursa). Corn semolina (Semolina, Corn Semolina Food Industry and Trade Inc., Samsun), Ustam pastry and pastry oil (Marsan, Adana), egg powder (A.B Food, Balıkesir), milk powder (Pınar Milk, İzmir) was used. Potato starch (Soyyiğit Food, Istanbul) was added to the formulas using chestnut flour and buckwheat flour. In addition, mono-diglycerides (MD), sodium stearoyl-2-lactylate (SSL), (Polen Flour and Food Additives Industry Inc., Istanbul), baking powder (Dr. Oetker, İzmir), drinking water (Palandöken Desni, Erzurum) and crystal granulated sugar obtained from the market were used.

Formula Optimization and Revani Production

After conducting the Response Surface Method (RSM) trial, patterns were created for optimizing the formula of both control and gluten-free revanis. The revanis were then produced using a Kitchen Aid Mixer (Model KSM45) in accordance with the AACC standard Method 10-90 (AACC-2000). After placing the other components, except for water, into the mixing bowl, 60% of the water was added. The mixture was then mixed for 30 seconds at low speed (Revolution-2) and 4 min at medium speed (Revolution-4). Next, half of the remaining water was added and mixed for 30 seconds at cycle-2, followed by an additional 2 min of mixing at cycle-4. Finally, the rest of the water was added and mixed for another 30 seconds in cycle-2 and 2 min in cycle-4. After greasing the revani baking pans (Ø: 15 cm, height: 3.5 cm) with pan oil, the prepared revani dough was divided into two pans, with each pan containing approximately 250 g of dough. The controlled revani (CR) produced with wheat flour, revani produced with rice flour (RR), revani produced with chestnut flour (CNR), and revani produced with buckwheat flour (BWR) were baked in an oven (PS5. Köseoğlu Heat Company Istanbul) at a temperature of 150±5 °C, determined through preliminary experiments. The cooking times were 28 min for CR, 29 min for RR, 32 min for BWR, and 27 min for CNR (Table 1).

Table 1. Fixed and optimized ingredients and ratios included in the formula of control and gluten-free revanis

Components	CR (g)	RR (g)	CNR (g)	BWR (g)
Wheat flour	7.5-17.5	-	-	-
Rice flour	-	50	-	-
Chestnut flour	-	-	25	-
Buckwheat flour	-	-	-	25-35
Corn semolina	-	50	50	30-50
Wheat semolina	85-95	-	-	-
Potato starch	-	-	25	25-35
Water	60-80	70-90	50-70	70-90
Sortening	43.75	43.75	43.75	43.75
Emulsifier	0.5	-	-	0.5
Sugar	50	50	50	50
Baking powder	5	5	5	5
Milk powder	7.5	7.5	7.5	7.5
Egg powder	10-20	10-20	10-20	10-20

Egg powder: (Egg white powder and egg yolk powder are in equal proportion.)
CR: Control revani, RR: Rice revani, CNR: Chestnut revani, BWR: Buckwheat revani

Revani Syrup (Sherbet)

While revani is baking in the oven, the revani syrup is prepared. The amount of syrup for revani is determined through preliminary experiments using the same measuring cups that were used for the revani dough. For the 250 g measuring cups, 200 g of granulated sugar and 250 mL of water were placed in a pot and boiled over low heat for about 15 min. The sherbet was stirred slowly with a spoon until it boils. When the sherbet starts to boil, 3-4 drops of lemon juice were added. Boiling was continued for about 3 min. Then, it was removed from the stove and allowed to rest for 5 min. In this way, the consistency of the revani syrup is increased. After coming out of the oven, the revani was left to cool for 2 h. Once it had cooled sufficiently, the syrup was poured slowly and evenly over the revani, allowing it to seep in from all sides. It was then left to rest for 30 min, allowing the revani to absorb the syrup.

Dough Properties

The weight of the revani dough produced during the research was determined using measuring cup. Then, the weight of the dough was divided by the weight of water in the same container and the density (g/mL) was calculated (Anonymous, 1995).

Revani Features

The volumes of revani produced in the study were determined according to the AACC (Method 10–91). Revanis were weighed 2 h after being removed from the oven. Subsequently, the specific volumes were calculated by dividing the measured volumes of the Revani by their respective weights (Anonymous, 1995). The volume and symmetry indices of the baked revani were measured by modifying the AACC template method (Methods 10–91). Revanis were carefully cut in the middle after cooling. A, B, C, D and E values were read in the revani section using the plastic measuring template (Figure 1). Subsequently, using these values, indices were calculated as follows: Volume index (|B+C+D|), Symmetry index (|2*C-B-D|), and Uniform index (|B-D|). The cooking loss percentage was determined by comparing the weights obtained 2 h after removing the revanis from the oven with their initial weights (Anonymous, 1995).

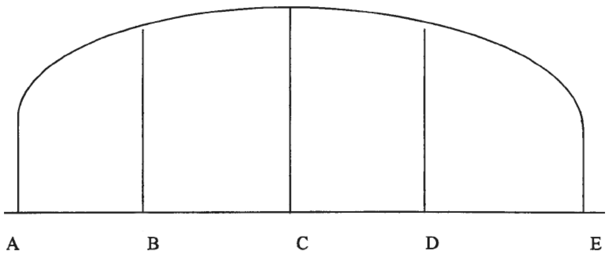


Figure 1. Measured points in the revani section

Determination of Textural Characteristics of Revanis

Textural properties of sherbet-less revanis were determined by TPA (Texture Profile Analysis) method using P/25 hardware in TA-XT Plus texture analyzer (Stable Micro Systems, Godalming, Surrey, UK). The test parameters are derived from a force-distance relationship. Based on these parameters, the following attributes were assessed: hardness, chewiness, gumminess, springness, and resilience. Hardness is determined as the maximum force recorded during the initial compression of the sample in the TPA test (the force required to compress the samples by 25%). The chewiness was obtained by multiplying the gumminess value with the elasticity value. Elasticity was calculated based on the time interval between the completion of the first compression and the initiation of the second compression. Gumminess was determined by multiplying the hardness and chewiness values. However, flexibility refers to the height value associated with the rebound that occurs in the revane after the applied pressure (Anonim, 2008).

Determination of Color Values of Revanis

The revanis were stored in JPG image format after being scanned using an HP Scan Jet 6400 C scanner with the HP Precision Scan LT program. Then L*, a* and b* values were calculated in the Lab Color Mod (16 Bits/channel) settings of these images. When the L value is 100, it indicates that the color is white. If the L value is 0, it represents black. A positive a value corresponds to red, while a negative a value represents green. Similarly, a positive b value indicates yellow, while a negative b value signifies blue (Doğan, 2002).

Consumer Testing (Sensory Analysis)

Sensory evaluation is very important as it reflects the consumer's taste, appeal, wishes, and desires about the quality of the product. The sensory evaluation of the control revani and the gluten-free revani, produced as a result of the studies, was conducted by a panel consisting of 14 individuals most of whom were faculty members of the Food Engineering Department. The panelists consist of 5 females and 9 males and their age range is 30-40. Revanis were presented to the panelists in numbered sample containers with water, crackers, and an evaluation form. The panel members independently evaluated these revani samples, considering parameters such as color, appearance, structure, odor, taste and aroma, crispness, mouthfeel, slice integrity, and overall acceptance. The evaluation form for each revani included these parameters, which were assessed using a hedonic scale (score ranges from 1 to 9). Then, the mean and standard errors of the given scores were calculated (Yildirim et al. 2018).

Statistical Analysis

The optimum levels of non-constant components in the formulation were determined by RSM for each revani. Revani desserts were prepared according to experimental design in order to performed gluten-free revani formulation closest to control revani dessert using StatGraphics Centrium 15.1 [StatGraphics, 2006] and CoStat statistical programs [CoHort, 2004]. CoStat statistics program was used for variance analysis and StatGraphics Centrium program was used for graphics.

The significance of the difference between the group means was determined using the LSD multiple comparison test at the $P<0.05$ level. The sensory evaluation results, which were conducted in two replications with 14 panelists participating each time, were statistically analyzed.

RESULTS

Optimizing Control and Gluten-Free Revani Formulas

In the study, the optimal levels of flour-semolina mixture, water, and egg powder for achieving the best control revani were initially determined. The Response Surface Method (RSM) presented in Table 2 was employed for this purpose. For the control revani, wheat flour and wheat semolina were utilized. To optimize the gluten-free formulas, the proportions of all other ingredients, except for the flour-semolina mixture, water, and egg powder from the control formula, were kept constant. After preliminary trials, it was decided to use rice flour, buckwheat flour, and chestnut flour for the production of gluten-free revani. Certain levels of potato starch have been added to buckwheat flour and chestnut flour. Potato starch was preferred because it supported the results positively.

In the preliminary trials, positive results were obtained by using the desired amount of water [water (g)/100 g] for the control revani, which was approximately in the range of 70-75 g. In addition, the rate of egg powder used in revani formulas was chosen at the level of about 15% and the product was successful.

In preliminary trials, it was determined that the use of emulsifiers for rice revanis did not differ significantly in terms of volumetric and flexibility evaluations. In the preliminary trials, the potential of using potato starch alongside buckwheat flour was explored to mitigate its unique taste, odor, and aroma, which could adversely impact consumer appeal. By incorporating potato starch and harnessing its functional properties, instead of using buckwheat flour alone, highly positive results were achieved. When chestnut flour was used as the only ingredient, the desired revani texture could not be achieved. The chestnut flour made the dough challenging to work with and resulted in an unstable appearance when baked in revani pans. Nevertheless, due to its pleasant aroma during dough preparation and appealing odor, chestnut flour was preferred in gluten-free revani production. In order not to use chestnut flour alone, a specific amount of potato starch was added, leading to positive outcomes. As a result of the preliminary experiments, the proportion of chestnut flour in the total flour quantity was determined as 50%, while the ratio of potato starch was established as 50%.

In preliminary trials, it was determined that the use of emulsifiers for rice revanis did not differ significantly in terms of volumetric and flexibility evaluations.

Table 2. Response Surface Method (RSM) trial design for control revani (CR) produced with wheat flour

Trial	WF-WS*	Water**	Egg powder***
1	1.00	-1.00	1.00
2	0.00	0.00	0.00
3	1.00	1.00	- 1.00
4	-1.00	1.00	1.00
5	- 1.00	-1.00	-1.00
6	0.00	0.00	0.00
7	-1.00	1.00	-1.00
8	0.00	0.00	0.00
9	1.00	1.00	1.00
10	-1.00	-1.00	1.00
11	1.00	-1.00	-1.00
12	0.00	0.00	0.00
13	1.63	0.00	0.00
14	0.00	-1.63	0.00
15	0.00	1.00	-1.63
16	0.00	1.63	0.00
17	0.00	0.00	1.63
18	0.00	0.00	0.00
19	1.63	0.00	0.00
20	0.00	0.00	0.00

*flour/semolina (g)/102.5 g flour: 1.00 = 7.5/95 g; 0.00 = 12.5/90 g; -1.00 = 17.5/85 g; 1.63 = 4.35/98.15 g; -1.63 = 20.65/81.85 g
**water (g)/102.5 g flour: 1.00 = 80 g; 0.00 =70 g; -1.00 = 60 g; 1.63 = 86.33 g; -1.63 = 53.67 g
***egg powder (g)/102.5 g flour: 1.00 = 20 g; 0.00 = 15 g; -1.00 =10g; 1.63 = 23.15g; -1.63 = 6.85 g

In the preliminary trials, the potential of using potato starch alongside buckwheat flour was explored to mitigate its unique taste, odor, and aroma, which could adversely impact consumer appeal. By incorporating potato starch and harnessing its functional properties, instead of using buckwheat flour alone, highly positive results were achieved. When chestnut flour was used as the only ingredient, the desired revani texture could not be achieved. The chestnut flour made the dough challenging to work with and resulted in an unstable appearance when baked in revani pans. Nevertheless, due to its pleasant aroma during dough preparation and appealing odor, chestnut flour was preferred in gluten-free revani production. In order not to use chestnut flour alone, a specific amount of potato starch was added, leading to positive outcomes. As a result of the preliminary experiments, the proportion of chestnut flour in the total flour quantity was determined as 50%, while the ratio of potato starch was established as 50%.

Dough density

While preparing the revani dough, since it traps plenty of air in the dough during the mixing process, it affects the cooking conditions of the revani and in this case, causes the density of the dough to decrease.

The density values of revani doughs were as follows: control revani (CR) had a density range of 0.83-0.94 g/mL, rice flour-based revani (RR) had a density range of 0.87-1.00 g/mL, buckwheat flour-based revani (BWR) had a density range of 0.84-1.01 g/mL, and chestnut flour-based revani (CNR) had a density range of 0.87-1.06 g/mL. The most important factor affecting the CR dough density was the different levels of water and egg components. While the dough density decreased as the amount of water used in the formula increased ($p<0.05$), the density of the revani significantly increased with the increase in the amount of egg powder ($p<0.01$). In the wheat flour/wheat semolina mixtures used in the formula, the effect of increasing the semolina ratio and decreasing the flour ratio on the dough density was found to be statistically insignificant ($p>0.05$). The increase in the amount of water and eggs in rice and buckwheat revanis was statistically insignificant ($p>0.05$). Chestnut flour-based revanine (CNR) the increase in the amount of water added to the formula significantly decreased the dough density (p<0.01), while the increase in the amount of egg powder increased the dough density at a statistically insignificant level (p>0.05).

Volume

Volume is a particularly visually important criterion in the product. Revanis, which are full in terms of volume, indicate that the mixing stage of the product is stable and that the raw materials are chosen in close to optimum amounts. The volumes of Revanis ranged from CR (385-510 mL), RR (425 - 475 mL), BWR (390 - 580 mL) and CNR (390 - 490 mL), respectively. Increasing the amount of egg powder significantly increased the volume of revani (p<0.01). The effect of the amount of water added to the formula on the volume of the revani is insignificant. Similarly, increasing the semolina ratio and decreasing the amount of flour in the control flour-wheat semolina mixture also have an insignificant effect on the volume of the revani. While the increase in the amount of egg powder in rice flour-based revanis increased the volume of the revani (p<0.05), the increase in the amount of water significantly decreased the volume of the revani (p<0.01). As the amount of egg powder increased in buckwheat revanis, the volumes of the obtained revanis increased significantly (p<0.01). Additionally, the effect of decreasing the semolina ratio and increasing the flour ratio in the buckwheat flour-corn semolina mixture significantly increased (p<0.01), while the increase in the amount of water decreased the volume of the revani (p<0.05). In chestnut flour-based revanis, the increase in the amount of water and egg powder resulted in a statistically insignificant increase in the revani volume (p>0.05).

Cooking loss

Considering the product's market supply, the cooking losses in the products play a significant role in the packaging design process. Cooking loss of revanis ranged between CR (7.53-19.71%), RR (9.08% - 22.3%), BWR (11.99% - 20.99%) and CNR (11.88% - 16.09%), respectively. In the wheat flour-wheat semolina mixture, the effect of increasing the semolina ratio and decreasing the flour ratio on the cooking loss of the control revani is statistically insignificant. Additionally, it was found that increasing the amount of egg powder had a statistically insignificant effect on reducing the cooking loss of revani (p>0.05). Statistically the effect of increased amounts of egg and water on the cooking loss of rice revanis was also insignificant (p>0.05). In the case of buckwheat flour-corn semolina mixture increasing the flour ratio and decreasing the semolina ratio resulted in a statistically reduction in the cooking loss of the revanis (p>0.05). While the increase in the amount of water in chestnut revani increases the cooking loss (p<005), the increase in the amount of egg powder has no effect on the cooking loss (p>0.05).

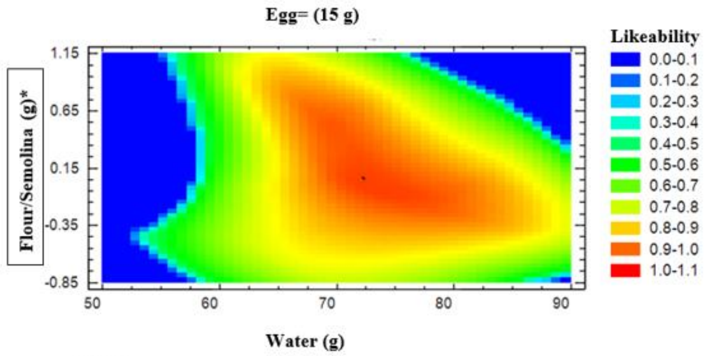
Variation of Textural Properties in the Optimization of Revani Formulas

Hardness

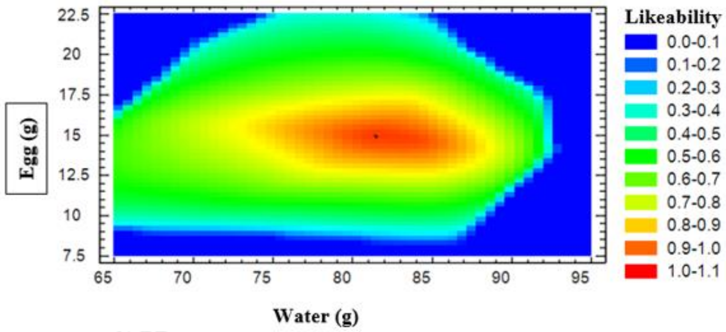
It was observed that the increase in the amount of egg powder significantly increased the hardness of the control revanis (p<0.01). However, the effect of increasing the semolina ratio and decreasing the flour ratio in the wheat flour/semolina mixture was found to be statistically insignificant (p>0.05). Additionally, as the amount of egg powder increased in all groups, it was observed that the hardness of the revani increased significantly (p<0.01). In the buckwheat flour/corn semolina mixture used in the formula, the effect of increasing the flour ratio and decreasing the semolina ratio on the hardness of the revani is insignificant (p>0.05).

Gumminess and Chewiness

It was observed that as the amount of water (p<0.05) and egg powder (p<0.01) increased in all revani groups, the chewiness and gummy values of the revanis increased significantly.

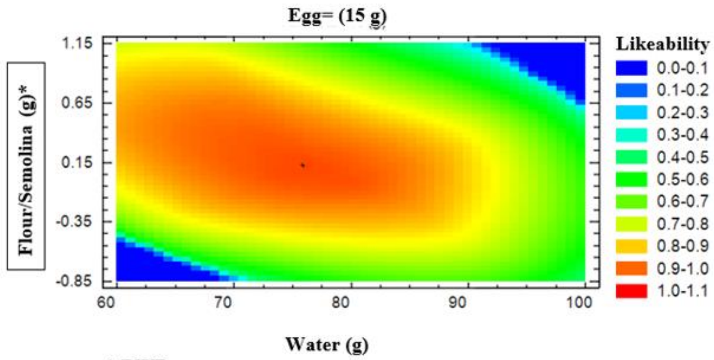


a) CR

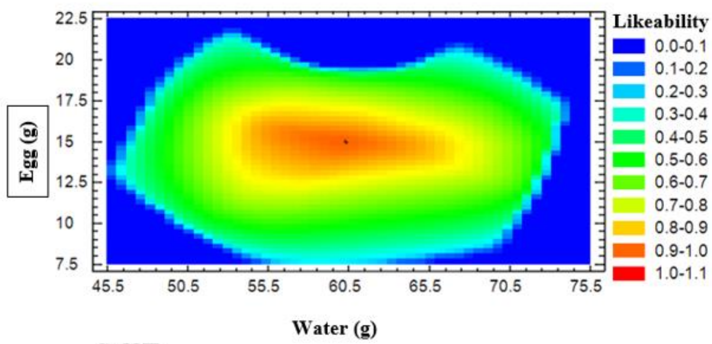


b) RR

***flour/semolina mix (g)/102.5 g flour,**
0.13=11.85/90.65
0.00= 12.5/90 g



c) BWR



d) CNR

***flour/semolina mix (g)/100 g flour,**
0.25=62.5/37.5
0.00= 60/40 g

Figure 2. Total likeability values of revanis (CR, RR, BWR, CNR)

Resilience

The interaction of egg powder and water mixture and water and wheat flour-wheat semolina mixture is significant ($p<0.01$). Increasing the semolina ratio and decreasing the flour ratio in the wheat flour - wheat semolina mixture hardens the revanis. However, increasing the amount of water reduces the flexibility of the revanis. The increase in the amount of egg powder increases the flexibility of the revani in a statistically insignificant way ($p>0.05$). In the rice study, it was observed that as the amount of water added to the formula increased, it first decreased the flexibility of the revani, then increased it significantly ($p<0.01$). The increase in the amount of egg powder increased the flexibility of the revani statistically insignificantly ($p>0.05$). The effects of egg powder, buckwheat flour-corn semolina mixture and water amounts are significant ($p<0.05$). In the study conducted with chestnut flour, it was determined that the flexibility of the products increased significantly as the amount of egg powder increased ($p<0.01$).

Elasticity (Springness)

It was observed that as the amount of egg powder and water increased, the elasticity of control revanis ($p<0.05$), rice and chestnut revanis ($p<0.01$) increased. In buckwheat products, the increase in the amount of egg powder ($p<0.001$) and water ($p<0.05$) was found to be very important in terms of elasticity.

Formula Optimization

One of the most important methods desired in product development studies is the optimization of multiple factors and the use of likability values. For this purpose, RSM is widely used (Doğan and Yıldız, 2010). The likability value, which was used for the first time in 1965, was obtained by converting the examined quality characteristics to a scale ranging from 0 to 1. When all factors are considered collectively, the average likability value is obtained. This is the geometric mean of the likability values of each factor (Akbaş, 2009). It was possible to produce the closest gluten-free revani when using wheat flour - wheat semolina mixture of 11.85% - 90.65%, 72.25% water and 15.85% egg powder together with the fixed components in the control system. While using 81.46% water and 14.91% egg powder with fixed ingredients in RR, gluten-free revani can be produced closest to control revani dessert, while in BWR, buckwheat flour – corn semolina mixture with fixed ingredients is 62.5% - 37.5% (BWR : 31.25% buckwheat flour + 31.25% potato) starch), using 75.85% water and 14.73% egg powder, the closest gluten-free revani to the control revani was produced. Finally, in the CNR, when 60.30% water and 14.95% egg powder were used together with the fixed components, the closest revani to the control revani was produced (Figure 2).

Sensory Evaluation

Gluten-free revanis produced with control flour, rice flour, buckwheat flour and chestnut flour were subjected to sensory analysis. Panelists evaluated each revani in terms of colour, appearance, texture, odour, taste and aroma, crispness, mouthfeel, slice integrity and general acceptance (Table 3).

The differences between general acceptance and color ($p<0.01$), as well as mouthfeel, appearance, and slice integrity ($p<0.05$), which are parameters used in sensory analysis were statistically significant. Control revanis received the highest scores in terms of color, odor, taste, aroma, mouthfeel, and appearance, while buckwheat revani received the lowest scores.

While there was no statistically significant difference between the produced revani in terms of structure ($p>0.05$), the highest score was rice revani, and the lowest score was gluten-free revani made with buckwheat flour. It is stated that revani made with buckwheat flour leaves a slightly bitter taste in the nose after swallowing. There is a significant difference between the produced revanis in terms of taste and aroma at $p<0.01$ level. Control and rice revani received the highest score in terms of crispness, while buckwheat revani received the lowest score. Regarding slice integrity, rice revani obtained the highest score, while gluten-free revani made with chestnut flour received the lowest score. Overall, control revani received the highest score, whereas gluten-free revani made with buckwheat flour received the lowest score. In terms of likability, the revanis are ranked as follows: control revani, rice revani, chestnut revani, and buckwheat revani.

Table 3. Sensory evaluation scores of gluten-free revanis produced with control and three different formulas

Parameters	CR±SE	CNR±SE	BWR±SE	RR±SE	LSD	P-value
Color	7.93±0.27^{b}	6.64±0.27^{b}	5.96±0.27^{a}	7.54±0.27^{a}	0.77	0.0000
Appearance	7.61±0.25^{a}	6.64±0.25^{bc}	6.07±0.25^{c}	7.25±0.25^{ab}	0.72	0.0002
Structure	7.11±0.26^{a}	6.54±0.26^{ab}	6.36±0.26^{b}	7.21±0.26^{a}	0.73	0.0546
Odor	6.75±0.29^{b}	6.07±0.29^{ab}	5.68±0.29^{ab}	6.18±0.29^{b}	0.82	0.0812
Taste/Flavor	7.00±0.27^{a}	6.43±0.27^{a}	5.21±0.27^{b}	6.47±0.27^{a}	0.78	0.0001
Friability	6.96±0.29^{a}	5.96±0.29^{b}	5.82±0.29^{b}	6.96±0.29^{a}	0.83	0.0055
Mouthfeel	6.96±0.31^{a}	6.25±0.31^{a}	5.04±0.31^{b}	6.61±0.31^{a}	0.87	0.0002
Slice integrity	7.29±0.27^{a}	6.21±0.27^{b}	6.36±0.27^{b}	7.64±0.27^{a}	0.78	0.0005
General Admission	7.25±0.25^{a}	6.61±0.25^{a}	5.36±0.25^{b}	6.89±0.25^{a}	0.73	0.0000

All parameters were compared separately. Different lowercase letters within each parameter indicate significant variation
*CR= control revani; CNR= chestnut revani; RR= rice revani; BWR= buckwheat revani
(by LSD test, p<0.05; SE: standard error.

DISCUSSION AND CONCLUSION

Gluten-free revanis prepared as RR, BWR and CNR optimized in the gluten-free revani production study were compared with the CR produced with wheat flour. The Response Surface Method (RSM) was used in the optimization phase. Water levels, egg powder amounts, starch amounts, flour and semolina ratios played an important role in obtaining the best revani. Many additives are used in the production of gluten-free revani (Sciarini at al., 2023). Emulsifier levels (0.6, 0.8, 1.0, 1.2) and varieties (DATEM, SSL, MDG) were tested in the preliminary trials of making rice revani. Emulsifier was not used in gluten-free rice revanis and gluten-free chestnut revanis, since no significant difference was detected in terms of textural and volumetric properties in the preliminary trials. Egg yolk powder and egg white powder were used as eggs. In order to stabilize the egg yolk-white ratio, the use of eggs sold in the market was not preferred during the study.

It has been stated that the use of eggs in cake production contributes to the formation of a protein matrix in the cake, provides volume increase by effective rising, gives the cake a crispy structure, adds nutrients, color and flavor (Pyler, 1988; Maziya-Dixon et al., 1994).

It was decided to use powdered milk instead of yogurt, which is usually used in Revani products. Thus, the irregular fluctuations in the ratio of water and dry matter, which may occur with the addition of yogurt, are prevented. In a study on gluten-free tulumba, the increase in the ratio of potato starch in corn flour-potato starch and buckwheat flour-potato starch mixtures decreased the firmness value of the tulumba and masked the undesirable unique taste and aroma of corn flour (Bulut, 2014).

In gluten-free revanis made with buckwheat and chestnut flour, the dough was supplemented with certain percentages (30, 40, 50) of potato starch and lentil starch. During the preliminary trials, potato starch demonstrated the best performance in terms of taste, aroma, and structure among the added starches. Due to the distinctive aroma, scent, and taste of buckwheat flour, which could yield unfavorable taste results in revani, gluten-free potato starch made with buckwheat flour was utilized instead.

In a study on the chemical, nutritional and technological properties of buckwheat; It was stated that tissue durability increased and cooking losses decreased in a noodle product made using buckwheat flour. It has been reported that while biscuit products have high moisture and aw values, sugar, protein and aroma components are higher in bread (Yıldız and Yalçın, 2013). The preference for buckwheat flour in Revani dessert can be associated with this feature of the flour. In the gluten-free cake study in which chestnut flour-potato starch was used, the increase in starch increased the specific volume of the cakes and decreased the hardness value (Yıldız, 2010). In the revani study, the use of potato starch increased the volumetrically and decreased the hardness value, especially in the buckwheat revani.

Shih et al. (2006) conducted a study investigating the impact of incorporating 10-40% sweet potato flour into rice flour for gluten-free pancake production. They found that the hardness and chewiness values of the pancakes decreased with the increase in potato flour content. In the present revani study, potato starch was not added to the rice flour-based revani. As a result, the high hardness and chewiness values observed in the revani align with these findings.

Kadan et al. (2001) reported in their study that rice bread produced using a bread machine had a lower volume, a harder texture, and was more prone to retrogradation during storage than wheat bread. In our study of revani, it was seen that the volume of the revani produced with rice flour is lower than the ones produced with other flours, and the structure is firmer.

Corn flour, starch, rice flour, and other starches are commonly utilized in the preparation of gluten-free products due to their absence of gluten proteins, which are crucial for bakery product production (Sıvaramakrishan et al., 2004). In the revani study, the addition of gluten-free ingredients like corn semolina and chestnut flour to the mixture resulted in improved dough workability, as well as the creation of a firm and voluminous revani.

The ingredients used in the production of gluten-free revani prepared with different flours (corn, rice, potato) and starches (corn, tapioca) affected the air bubbles in the product. Additionally, revani made with corn (62.5%) and rice (37.5%) flour mixtures had better sensory properties (Yildirim et al., 2018).

In a study on the evaluation of bread, cake and biscuit varieties prepared with chestnut flour and gluten-free flours for celiac patients by sensory analysis, bread produced from a single type of flour was discussed in terms of general desirability. In the study, it was determined that the products prepared from chestnut flour were the most preferred products among the groups (Seferoğlu, 2012). Due to this particular characteristic of chestnut flour, it can be considered a crucial choice in the gluten-free revani study compared to other flours. In a study on gluten-free noodles, it was found that the noodles needed to absorb a significant amount of water during cooking. Insufficient water absorption resulted in the noodles being hard after cooking (Bhattacharya et al., 1999). In the production of revani, water is added to the dough in specific proportions to ensure that the semolina absorbs water during cooking and swells. This contributes to maintaining moisture within the revanis, preventing early hardening and avoiding crust burning during cooking.

The amount of water added to the medium constituted an important criterion in terms of volume in the revanis. The fact that the amount of water is above or below the optimum has led to volume losses in the revanis. While the decrease in the amount of water is desired in terms of volume, it is not desired in terms of structure. Another important criterion in the optimization of revani is the amount of egg powder Egg powder holds a significant role in revanis as it provides essential protein for achieving the desired volume, shaping the dough, and enhancing the overall appeal of gluten-free preparations.

Since gluten-free revanis are devoid of gluten, eggs have a great role in this context. Egg powder played an important role in eliminating the deficiency of gluten protein, and contributed to the volume and structure of the revani together with milk powder. Egg powder at the rate of 15% was effective in obtaining the optimum level of product.

Upon considering all the revanis, the scores provided by the panelists indicate that the gluten-free revanis performed comparably to the control revanis. The lower score for gluten-free revani made with buckwheat flour can be attributed to the distinctive flavor associated with buckwheat flour. Furthermore, the study suggests that it has reached an acceptable level, taking into account the unique aroma and slightly bitter taste of corn semolina, as well as consumers' perceptions of consuming revanis made with wheat flour and wheat semolina.

The study, it was helped to meet the sweet demands of celiac patients and an alternative was presented to them. Economically; It is thought that it will provide a great advantage to consumers in terms of being a product that can be easily offered on dessert menus, in cafes and discount stores.

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Conflict of Interest

Kör makalede bu alan boş bırakılmalıdır. Bu bölüm başlık sayfasında yazılmalıdır.

Yazar Katkısı

The article authors declare that there is no conflict of interest between them.

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