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Optimization of Gluten-Free Tulumba Dessert Formulation Including Corn Flour: Response Surface Methodology Approach

Önder Yildiz, Birgül Bulut*

Department of Food Engineering, Faculty of Engineering, Igdir University, 76000-Igdir, Turkey

Key words: celiac diseases, corn flour, potato starch, gluten-free tulumba dessert, RSM

Tulumba dessert is widely preferred in Turkey; however, it cannot be consumed by celiac patients because it includes gluten. The diversity of gluten-free products should be expanded so that celiac patients may meet their daily needs regularly. In this study, corn flour (CF) / potato starch (PS) blend to be used in the gluten-free tulumba dessert formulation was optimized using the Response Surface Methodology (RSM). Increasing ratio of PS in the CF-PS led to a decrease in hardness of the dessert and to an increase in expansion, viscosity, adhesiveness, yield of dessert both with and without syrup ($P<0.05$). When considering the properties used in optimization process, the optimum formulation was found to be as 201.52 g water and 0.18 g CMC and 100 g blend of CF-PS at the rates of 59:41. In sensory evaluation test, appearance, symmetry, crispness and aftertaste properties of the gluten-free dessert prepared from this formulation were very close to control sample ($P>0.05$), additionally these desserts had a much higher sensory score compared to the control sample in terms of the overall quality and pore structure ($P<0.05$).

INTRODUCTION

Being native to Turkish cuisine, Tulumba dessert is donut-like product which are likely consumed by most of the Turkish people. This dessert is prepared by immersing the fried dough pieces in the syrup. Generally, different additives could be added to improve the quality of the dessert. We can add cereal products (semolina, semolina flour, corn flour, rice flour, gluten flour and wheat starch) to increase the hardness and crispiness; emulsifiers to regulate the texture and internal structure; sweetener to render it more appealing in terms of color and taste, and milk and milk products to enhance the nutritional value of the end product [Özen, 2006].

By reason of the fact that tulumba dessert which is traditionally produced with wheat flour including gluten protein, it cannot be consumed by celiac patients. Using adult blood donors, prevalence rates for celiac disease in Turkey were 1:87 (1.2%) [Tatar *et al*., 2004]. Similar prevalence rates were determined in surveys of Turkish children as 1:115 (0.9%) [Ertekin *et al*., 2005]. These prevalence rates are almost identical to those of a variety of countries in Europe.

As an alternative to wheat flour; rice, buckwheat, corn and chestnut flours (none of them includes any gluten in their nature) and different starch types are used in different gluten-free products [Sanchez *et al*., 2002; Lopez *et al*., 2004; Shih *et al*., 2006; Lazaridou *et al*., 2007; Arendt & Bello, 2008; Ronda *et al*., 2009; Levent & Bilgiçli, 2011; Gularte *et al*., 2012; Witczak *et al*., 2012; Milde *et al*., 2012; Yildiz & Dogan, 2014]. However, as for starch, those except wheat are more preferable, because some celiac patients cannot even tolerate against wheat starch. The reason behind this is the slight possibility that gliadin can be mixed up with wheat flour even in very small amounts. Even this little quantity can disturb the celiac patients if is taken for a long period of time [Chartrand *et al*., 1997; Horvath & Mehta 2000; Lohiniemi *et al*., 2000].

The dough that was obtained as a result of the sole use of these flours in gluten-free product formulations does not show desired viscoelastic property. For this reason, in order to enhance the product quality, in recent years, there has been an increase in the number of the studies that aimed to improve the production techniques and additives that could be replaced by gluten [Savtekin, 2014].

The distinctive and unique odor of corn flour is one of the important factors that limit the use of corn. Nevertheless, despite this, corn flour is used as an additive in a great variety of flour products, especially out of its regard for enriching bread types is preferred [Özkaya & Özkaya, 1992]. In an attempt to settle the unfavorable aroma that is present in corn and buckwheat flours [Yildiz, 2010; Bulut, 2013] and to enhance the malleability of the dough in chestnut flour, it is suggested that potato starch could be included in the formulation [Yildiz & Dogan, 2014]. The gluten-free products are quite expensive when compared with traditional ones. The corn flour is advantageous in terms of both price and accessibility, and besides it can provide a significant contribution to the cost reduction of gluten-free based products.

* Corresponding Author:
E-mail: o.yildiz.36@hotmail.com (Önder Yildiz)

In recent years, it has been observed that in order to imitate the viscoelastic properties of gluten in dough in the preparation of the rice and corn flour-based gluten-free flours, the studies intended for the use of combination of starch, milk components and/ or hydrocolloids has increased [Arendt & Bello, 2008].

Alternatives on the market that the celiac patients can consume are quite limited. Varieties of the gluten-free products must be extended for these patients to keep a balanced diet. There are a few studies with regard to tulumba dessert. However, we have not come across any study related with the production of gluten-free tulumba dessert. This case increases the importance of the study further, because the gluten-free tulumba dessert possessing can improve the desired quality requirements which will be an alternative product for the celiac patients.

In this study, the formula of corn flour-based gluten--free tulumba dessert was optimized using Response Surface Method (RSM) and the effects of gluten-free components on some quality features of tulumba dessert were investigated.

MATERIALS AND METHODS

Materials

In the manuscript, for special purpose wheat flour that is a fine-textured, almost silky flour milled from soft wheat and has a low protein content with 9.50% and 0.48% protein and ash content, respectively (Söke flour, Söke Milling Industry and Trade Inc. Aydın, Turkey) was used for the production of control tulumba dessert; corn flour with a protein content of 5.50% and ash content of 0.62% (Aro-Tech, Food Industry and Trade Inc., Istanbul, Turkey) and potato starch (Soyyiğit Food Industry and Trade Inc., Istanbul, Turkey) were used. Carboxy methyl cellulose (CMC) and isolated soybean protein (SP) (Adler, KMK Laboratories Food Additives Industry and Trade Co. Ltd., Istanbul, Turkey), sunflower seed oil (Komili, Staple Food, Istanbul, Turkey), drinking water (Palandöken Desni, Erzurum, Turkey), fresh eggs and crystal sugar were procured from the local market in Igdır.

Production of tulumba dessert

The fixed and optimized ingredients with their amounts that were included in the formulation of tulumba desserts prepared with gluten-free mixture and with wheat flour (control) are shown in Table 1. Control tulumba dessert (WFD) prepared with wheat flour (WF) was produced according to the method described by Dogan & Yurt [2002]. Response Surface Method was used to optimize the formulation of corn flour-based gluten-free tulumba dessert.

When CF was used as a source of gluten-free flour, the unique flavor of the corn comes into question and the acceptability of the product is negatively affected. In order to suppress this unfavorable flavor and benefit from its functional properties, potato starch (PS) was tested in the preliminary tests and very positive results were achieved. In order to optimize gluten-free formulation with the blend of CF and PS, the experimental design of RSM given in Table 2 was used.

Determined as a result of the preliminary tests for each formulation, dough cooking time, kneading time to rub the eggs into the dough (Kitchen Aid Mixer, Model KSM45), initial temperature of frying oil, frying temperature and time are all shown in Table 3.

TABLE 1. The proportions of ingredients included in the formulation of tulumba desserts prepared with gluten-free mixture and wheat flour (control).

Ingredients	WFD (g)	CFF (g)
Wheat flour	100	–
Corn flour	–	50–70
Potato starch	–	30–50
Water	150	190–210
Vegetable oil	10	10
CMC	–	0.3–0.7
Egg white powder	40	40
Egg yellow powder	17	17

* WFD: tulumba formula with wheat flour (control); CFF: corn flour formula; CMC: Carboxy methyl cellulose.

TABLE 2. Response surface method (RSM) experimental design for corn flour formula tulumba dessert (CFFD).

Run	Coded values			Uncoded values		
	X1	X2	X3	PS	Water	CMC
1	-1.00	-1.00	-1.00	30	190	0.15
2	0.00	0.00	0.00	40	200	0.30
3	1.00	1.00	-1.00	50	210	0.15
4	-1.00	1.00	1.00	30	210	0.45
5	1.00	-1.00	1.00	50	190	0.45
6	0.00	0.00	0.00	40	200	0.30
7	1.00	1.00	1.00	50	210	0.45
8	0.00	0.00	0.00	40	200	0.30
9	-1.00	-1.00	1.00	30	190	0.45
10	-1.00	1.00	-1.00	30	210	0.15
11	0.00	0.00	0.00	40	200	0.30
12	1.00	-1.00	-1.00	50	190	0.15
13	0.00	0.00	0.00	40	200	0.30
14	-1.63	0.00	0.00	23.67	200	0.30
15	0.00	0.00	0.00	40	200	0.30
16	0.00	-1.63	0.00	40	183.67	0.30
17	1.63	0.00	0.00	56.32	200	0.30
18	0.00	0.00	1.63	40	200	0.05
19	0.00	0.00	-1.63	40	200	0.55
20	0.00	1.63	0.00	40	216.33	0.30

CMC: Carboxy methyl cellulose; SP: Isolated soybean protein.

TABLE 3. Pastry cooking, kneading time of tulumba desserts, oil temperature, frying time and temperatures.

Desserts	Pastry baking time (min)	Kneading with mixer (min)	Oil initial temperature (°C)	Frying temperature (°C)	Frying time (min)
Wheat flour formulation (control)	7.5	3.0	25	150	20
Corn flour formulation (CFF)	8.5	6.0	80	120	17

Characteristics of tulumba desserts

Determination of expansion (cm), oil absorption t and yield (%) values

The expansion values of tulumba dessert were measured with a manual micrometer. The oil absorption capacity of tulumba desserts was determined with the reduction in oil (600 mL) that was used during each frying and calculated as %. The yield values were calculated by means of the following formulations.

Yield of dessert without syrup (%) =

$$100 - \frac{\text{Unfrying dough weight} - \text{Weight of dessert without syrup}}{\text{Weight of dessert without syrup}} \times 100$$

Yield of dessert with syrup (%) =

$$100 - \frac{\text{Unfrying dough weight} - \text{Weight of dessert with syrup}}{\text{Weight of dessert with syrup}} \times 100$$

Determination of the textural properties of the desserts

Textural parameters of tulumba desserts (hardness, chewiness, cohesiveness, adhesiveness and springiness) were measured using a texture analyzer (TA-XTplus, Stable Micro Systems, Godalming, Surrey, UK) equipped with a load cell of 5 kg and a P/5 cylindrical probe according to texture profile analysis (TPA) method. The test conditions were pre-test speed 1 mm/s, test speed 1 mm/s, post-test speed 10 mm/s, distance 30 mm and trigger force 5 g.

Sensory analysis

As it reflects the appreciation and demands of the consumers regarding the quality of the product, sensory evaluation is highly important. The sensory evaluation of desserts was carried out by the instructors of Igdir University. The panelists were shortly informed about the evaluation criteria before the panel. The tulumba desserts were offered to the panel members using the numbered sample pots along with water and sensory assessment form. The appreciation levels were determined using hedonic scale.

Statistical analysis

The optimum levels of the components in the formulation for gluten-free tulumba dessert were determined with RSM. The desserts were prepared according to the experimental design (Table 2) in order to develop gluten-free tulumba formulation closest to control tulumba dessert using StatGraphics Centrium 15.1 [StatGraphics, 2006] and CoStat statistical programs [CoHort, 2004]. The level of significance between the factor averages was determined by means of LSD test at a level of P<0.05. Besides, sensory scores of 14 participated panelists were also subjected to statistical analysis.

TABLE 4. Properties of control tulumba dessert produced with wheat flour.

Tulumba dessert properties	Measured value
Expansion (cm)	2.77±0.047
Yield of dessert with syrup (%)	86.52±1.445
Yield of dessert without syrup (%)	73.86±1.436
Oil absorption (mL)	46.66±11.54
Hardness (g)	110.75±5.533
Chewiness	133.78±7.587
Adhesiveness (g.s)	-16.97±4.629
Cohesiveness	0.457±0.047
Springiness	2.273±0.167

RESULTS AND DISCUSSION

Production of control tulumba dessert

The results with regard to the evaluated properties of control tulumba dessert produced with wheat flour (WF) according to the formulation given in Table 1 [Dogan & Yurt, 2002] are shown in Table 4.

Production of gluten-free tulumba dessert

The effect of the components included in the model on the various properties of corn flour-based gluten-free tulumba desserts are shown in Table 2.

Expansion (cm)

The expansion values of gluten-free tulumba desserts produced using the blend of CF-PS varied between 1.83 and 2.44 cm. 88.21% of this total difference in the expansion values can be explained by the linear and quadratic effects of the components in the model (water, CF-PS blend and CMC) and by the interactions of components. The effect of CF-PS blend on the expansion was found to be statistically significant (P<0.001). As long as the PS rate in the blend rises up to the levels of approximately 45%, the expansion increases (Figure 1). The important effect of PS was also observed in the expansion value of buckwheat-based gluten--free tulumba desserts, which was reported by Bulut [2013]. Besides, the quadratic effects of water (P<0.01) and CF-PS blend (P<0.05) on expansion values were found as statistically significant.

In a study that was carried out by Bulut [2013], the expansion values of gluten-free tulumba desserts produced using BWF and PS varied between 1.87 and 2.74 cm, while the expansion values of gluten-free tulumba desserts produced using

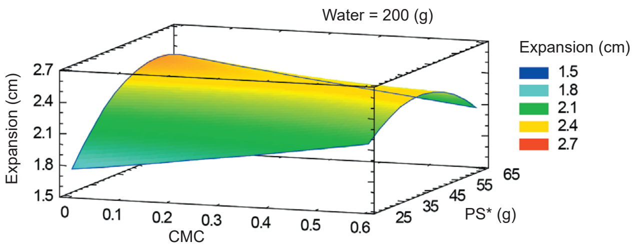

FIGURE 1. Effect of component levels on expansion of dessert with corn flour formulation.

*PS: Potato starch ratio (%) in the blend of corn flour and potato starch; CMC: Carboxy methyl cellulose

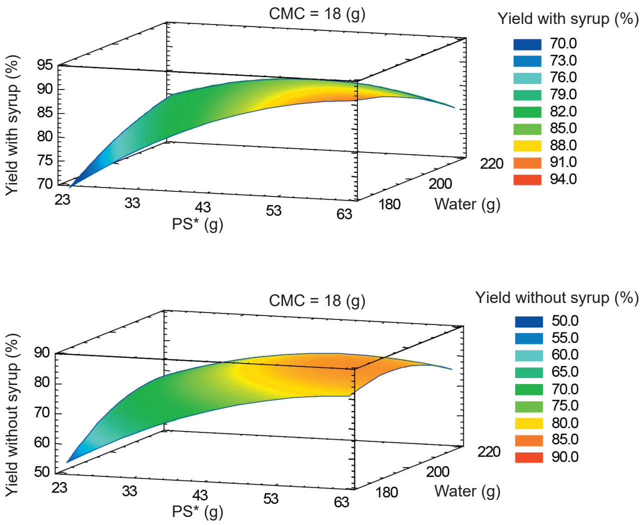

FIGURE 2. Effect of component levels on yield of tulumba dessert prepared corn flour formulation.

*PS: Potato starch ratio (%) in the blend of corn flour and potato starch; CMC: Carboxy methyl cellulose

rice flour (RF) varied between 2.14 and 3.19 cm. In another study, the expansion value of tulumba dessert produced with wheat flour was 2.495±0.42 cm [Özen, 2006], the expansion value of control tulumba desserts in this study however was determined as 2.77±0.047 cm.

Yield of dessert with syrup (%)

Yield of gluten-free tulumba desserts with syrup produced using CF and PS varied between 78.74 and 92.43%. A substantial part (72.10%) of the total difference in yield can be explained by linear and quadratic effects of factors and their interactions. Increasing PS rate in CF-PS blend statistically increased the yield of dessert with syrup (Figure 2) ($P<0.05$). Besides, the effects of CMC and the increasing levels of water, the quadratic effects of the components and the interactions on the yield value were found to be statistically insignificant ($P>0.05$).

The yield of dessert with syrup varied between 78.12 and 93.27% in a study [Bulut, 2013] in which the formulation of gluten-free tulumba dessert was developed using rice flour. It was found out that only the isolated soybean protein (SP) used at different levels had a statistically significant linear effect on the yield of gluten-free tulumba dessert with syrup ($P>0.05$).

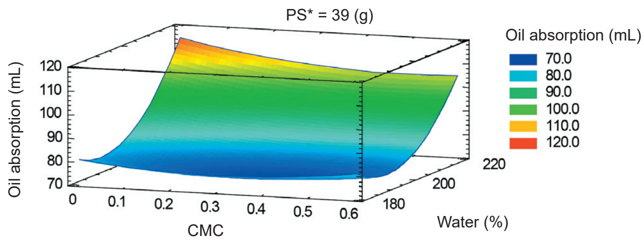

FIGURE 3. Effect of component levels on oil absorption of tulumba dessert with corn flour formulation.

*PS: Potato starch ratio (%) in the blend of corn flour and potato starch; CMC: Carboxy methyl cellulose

Yield of dessert without syrup (%)

Syrup-free yield of tulumba desserts produced with CF and PS varied between 67.37 and 89.90%. The 64.86% of this difference can be explained by the linear and quadratic effects of the components in the model (water, MU-PN blend and CMC) and their interactions. As in the yield of dessert with syrup, increase in PS rate in the CF-PS blend used in the formulation caused an increment in the syrup-free yield of the dessert (Figure 2). Being statistically important as well, this increase ($P<0.05$) showed how it was well-directed to select potato starch added to the formulation.

By this way, yield increased and the undesired flavor of CF was masked with PS. In a study [Bulut, 2013], buckwheat flour (BWF) and PS blend was used as a source of flour and the syrup-free yield values of gluten-free tulumba desserts produced varied between 59.84 and 85.71%. Critical factor affecting the yield was stated to be PS concentration in the mixture. In the same study, the syrup-free yield of gluten-free tulumba desserts with RF varied between 63.00 and 89.26%. This is a result of PS as indicated in the yield of dessert with syrup ($P<0.01$).

In the gluten-free cake, containing chestnut flour and potato starch, specific volume of the cakes improved with higher level of potato starch in the formulation [Yildiz & Dogan, 2014]. The most important functional feature of starch is how it reacts in accordance with heat in the presence of water. When blend of potato starch and water is heated over the critical control point (60°C for potato starch), the hydrogen bonds that hold the granule, becoming weaker, inflate and become several times bigger than initial size [BeMiller & Whistler, 2009]. The expansion and yield of tulumba desserts can be associated with this functional feature of starch.

Oil absorption (mL)

The oil absorption of gluten-free tulumba desserts prepared using CF and PS varied between 60 and 105 mL (10.0–17.5%). 49.75% of the change that took place in the oil absorption of the desserts can be explained by the linear and quadratic effects of water, CF-PS blend and CMC included in the model and by the interaction of components. As water level in the formulation was increased, the oil absorption of the tulumba desserts was also increased (Figure 3). As the amount of water that evaporates during the frying is higher.

The oil absorption in the products depends on the amount of water in the fried products [Chanderan *et al*., 1996]. The in-

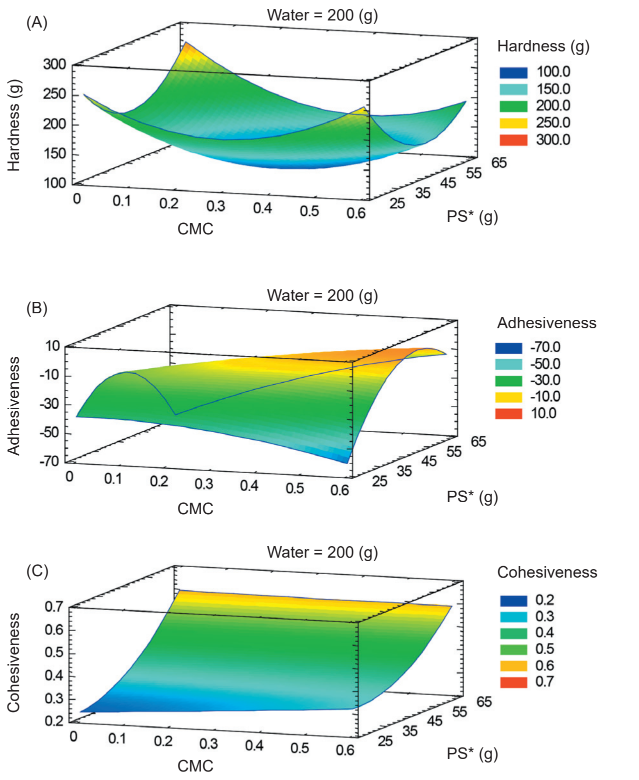

FIGURE 4. Effect of component levels on hardness (a), adhesiveness (b) and cohesiveness (c) of tulumba dessert with corn flour formulation.

*PS: Potato starch ratio (%) in the blend of corn flour and potato starch; CMC: Carboxy methyl cellulose

crease of the level of CMC partially decreases the oil absorption (P>0.05) because of the hydrophilic nature of CMC. A similar result was reported by Dogan & Yurt [2002]. In some formulations, gums are added to control viscosity and water holding capacity and to constitute gel and film with increased. The most important characteristic of gums is their thermal gelling in decreasing oil absorption. The researchers also associated that the oil absorption of tulumba was controlled by variety of factors such as frying temperature and frying load of electric fryer [Dogan & Yurt, 2002].

Determination of textural properties

Hardness (g)

The hardness value of gluten-free tulumba desserts prepared using CF-PS blend varied between 111.18 and 197.30 g. The quadratic effects of all of the components included in the model had a dramatically effect on the hardness value of tulumba desserts (P<0.01). The increasing PS in CF--PS blend decreased the hardness of the dessert (Figure 4) (P<0.01). In another study [Bulut, 2013], the hardness values of the tulumba desserts in which the BWF and PS were used as a source of flour varied between 89.34 and 161.25 g. The linear effect of BWF-PS blend on the hardness value of tulumba desserts (P<0.01) was found to be significant at the level of the effect of different water levels along with the quadratic effect of BWF-PS blend (P<0.05). Addition of water and potato starch at the higher level in the BWF-PS also decreased the hardness value. It was noted in a study of chestnut-based gluten-free cake that the hardness value of the cakes decreased with addition of potato starch into the formulation [Yıldız & Dogan, 2014]. Replacement of flour with wheat starch, vital gluten, different flours and semolina at 20% in the formulation; smoother tulumba dessert was obtained with addition of wheat starch into the tulumba desserts [Özen, 2006].

Adhesiveness (g.s)

The adhesiveness value of the gluten-free tulumba desserts produced using CF and PS varied between 58.30 and 6.17 g.s. 77.56% of the total difference in adhesiveness value of the dessert can be explained by the linear and quadratic effects of the components included in the model and their interactions. Upon the adhesiveness value, the linear effect (P<0.01) and the quadratic effect (P<0.05) of CF-PS blend used in the formula were statistically significant. As the PS in the CF--PS blend increases, the adhesiveness of tulumba desserts that are produced increases, as well (Figure 4). In a study carried out by Bulut [2013], the adhesiveness values of gluten-free tulumba desserts produced using buckwheat flour and potato starch varied between 72.65 and -7.08 g.s. Upon the adhesiveness, the similar effects of PS were reported.

Chewiness

The chewiness value of gluten-free tulumba desserts prepared with CF-PS varied between 34.22 and 182.60. The linear and quadratic effects and interactions can explain 62.74% of the total difference that took place in the chewiness value of tulumba dessert. The effects of the interaction of CMC and the blend of CP-PS on the chewiness value of the tulumba desserts was significant (P<0.05). Generally, the increase in water level in the formulation and the PS ratio in blend of CF-PS decreased the chewiness value.

Cohesiveness

The cohesiveness values of gluten-free tulumba desserts produced using CF and PS varied between 0.20 and 0.46. The 60.77% of the total difference that belongs to the cohesiveness value of this tulumba dessert can be explained by the linear and quadratic effects and interactions of the components included in the model. The linear effect of the CF and PS blend used in the formulation had a statistically significant effect on the cohesiveness value of the dessert (P<0.05). As long as the CMC and water ratio used in the formulation increases, the cohesiveness of the tulumba desserts that was produced increased as well. However, the effects of these linear and quadratic effects and the interactions of these components on the cohesiveness value was not statistically significant (Figure 4) (P>0.05).

In a study, the cohesiveness value of gluten-free tulumba desserts produced using BWF and PS varied between 0.22 and 0.65. The linear effects of water used in the formulation and the effects of water and isolated soybean protein-carboxy methyl cellulose (SP-CMC) interactions on cohesiveness value were found to be statistically significant (P<0.05). The different water and SP levels used in the formulation had a statistically significant effect on the cohesiveness value. In addition, the cohesiveness value was also affected by the quadratic effect of SP and SP-CMC interactions (P<0.05) [Bulut, 2013].

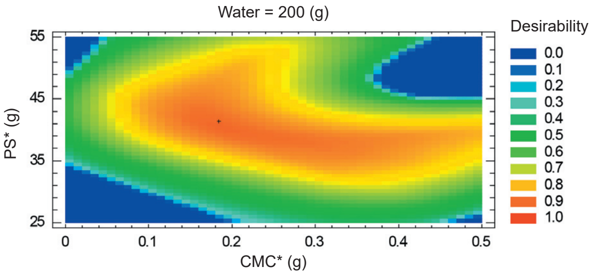

FIGURE 5. Total desirability values of corn flour–potato starch blends, carboxy methyl cellulose and water levels.

PS: potato starch g/100 g corn flour–potato starch blend; g water/100 g flour blend; CMC: carboxy methyl cellulose g/100 g flour blend

Springiness

The springiness value of the gluten-free tulumba desserts produced using the blend of CF-PS varied between 0.46 and 2.24. As long as the water ratio used in the formulation increased, the springiness value decreased. Yet, the linear and quadratic effects of the components included in the model as well as the effects of interactions between the components on springiness value were not statistically significant (P>0.05).

Formulation optimization

One of the most significant methods preferred in product development studies is the optimization of multiple factors and the usage of appreciation values. This is the reason why RSM is commonly used [Dogan & Yildiz, 2010]. Having been used for the first time by Harrington [1965], the appreciation value is obtained as a result of the transformation of the analyzed quality properties into the scale ranging between 0 and 1. When the factors are evaluated all together, the average total appreciation value is obtained. The value is the geometric average of the appreciation values that belong to each factor [Akbas *et al.*, 2012].

The water level in the formulation of gluten-free tulumba desserts produced with the blend of CF and PS as a flour source, and the effects of the changes in the amount of PS and CMC in CF&PS blend on appreciation level are shown in Figure 5. Considering all factors evaluated in the study, it became possible to produce gluten-free tulumba dessert being closest to the control tulumba dessert adding 201.53 g water, 0.18 g CMC and 100 g CF-PS blend at the rate of 59:41 along with the fixed components (Figure 5). In the evaluation employing the adhesiveness, chewiness, cohesiveness, resilience, hardness, expansion, yield values and oil absorption of tulumba desserts, the appreciation value was found to be 0.911 (Table 5).

Sensory evaluation

The control tulumba dessert produced using wheat flour (WF) and the corn flour-based gluten-free tulumba dessert were also compared in terms of sensory attributes. The panel members evaluated each tulumba dessert in terms of their appearance, pore structure, symmetry, crispness, taste and aroma, the mouth feel and overall quality. The points that were given by the panelists and their statistical comparisons are shown in Table 6.

TABLE 5. Predicted and measured values for the responses (independent variables) at optimum CF-PS blend, CMC and water levels for tulumba dessert.

Tulumba dessert properties	Predicted value	Measured value
Expansion (cm)	2.34	2.39
Yield of dessert with syrup (%)	86.12	84.71
Yield of dessert without syrup (%)	80.40	81.26
Oil absorption (mL)	80.00	80.00
Hardness (g)	127.62	121.53
Adhesiveness (g.s)	-13.23	-11.36
Chewiness	64.24	65.71
Cohesiveness	0.32	0.30
Resilience	0.07	0.08
Desirability	0.911	

TABLE 6. Sensory evaluation scores for control and gluten-free tulumba dessert*.

Parameters	Gluten-free dessert Scores ± SE	Control dessert Scores ± SE	LSD
Appearance	7.092±0.49[a]	6.042±0.49[a]	1.363
Pore structure	6.964±0.61[a]	4.928±0.61[b]	1.753
Symmetry	7.821±0.44[a]	7.092±0.44[a]	1.248
Crispness	7.450±0.49[a]	7.100±0.49[a]	1.404
Flavor	7.700±0.49[a]	6.221±0.49[b]	1.396
Aftertaste	8.035±0.46[a]	7.057±0.46[a]	1.327
Overall quality	7.921±0.35[a]	6.778±0.35[b]	0.994

*Parameters were compared separately. Different small letters indicate that they are significantly different from each other when compared within each parameter (by LSD test, p<0.05; SE= standard error).

By taking into consideration all the properties of control and gluten-free tulumba desserts, the points that they got from the panelists regarding their appreciation values are respectively 6.778 and 7.921 (Table 6). Statistically, much more significant difference between both of the tulumba desserts in terms of their appreciation values was found (P<0.05).

CONCLUSIONS

Response Surface Method was used for the purpose of optimizing the formulation of gluten-free tulumba dessert prepared using CF and PS blend instead of wheat flour.

With an attempt to suppress the unique flavor of CF which affects the consumer demand negatively, PS was added to the formulation to benefit from its functional characteristics. PS used with similar purposes both in corn formulation and in chestnut flour formulation in the study of gluten-free cake [Yildiz, 2010].

While increasing potato starch level in the CF and PS blend decreased the hardness value of the dessert, it increased the expansion, adhesiveness, resilience values as well as syrup yield and syrup-free yields. Being statistically important, as well, this increase ($P<0.05$) shows how it was well-directed and feliticious decision to select potato starch added to these flours. Thus, the yield increased and not favorable flavor of CF was masked with PS. The increase in the expansion and yield of tulumba desserts may be associated with the gelatinization of starch.

In this study, when 59% CF and 41% PS blend, 201.53% water and 0.18% CMC were used along with the constant components, gluten-free tulumba dessert being closest to the control tulumba dessert was produced. Taking into account all of the properties of these desserts, the appreciation value became 0.911. According to the results of the present study, similar gluten-free products could be produced using RSM to increase alternative gluten-free products.

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