NÖHÜ Müh. Bilim. Derg. / NOHU J. Eng. Sci., 2024; 13(4), 1492-1497

Niğde Ömer Halisdemir Üniversitesi Mühendislik Bilimleri Dergisi
Niğde Ömer Halisdemir University Journal of Engineering Sciences

Araştırma makalesi / Research article

www.dergipark.org.tr/tr/pub/ngumuh / www.dergipark.org.tr/en/pub/ngumuh

Investigation of cake production with the addition of lupin (*Lupinus albus*) flour

Termiye (*Lupinus albus*) unu ilavesi ile kek üretiminin araştırılması

Sinem Gökal[1], Mehmet Yetişen[2,*], Cem Baltacıoğlu[3]

[1,2,3] *Niğde Ömer Halisdemir Üniversitesi, Gıda Mühendisliği Bölümü, 51240, Niğde Türkiye*

Abstract

This study investigated the effects of lupin flour addition on the physicochemical, textural, and sensory properties of cakes. It was found that the protein content of cakes increased from 6.13% to 17.50% with the addition of lupin flour in specific proportions, while the color values of the cake crust were also enhanced. The results indicated no significant difference in both moisture and total oil content of the cake samples with lupin flour addition; however, a decrease in the volume and carbohydrate content of the cakes was observed. Increasing the amount of lupin flour led to a reduction in the textural properties of the cake samples, such as springiness, cohesiveness, gumminess, chewiness, and resilience, while the change in hardness was found to be insignificant. Statistically significant changes were also noted in the sensory attributes of the cakes, particularly in taste, softness, and general acceptability. Overall, it was concluded that the use of lupin flour in cake production makes significant contributions to the nutritional content of the cakes.

Keywords: Lupin flour, Physicochemical, Sensory, Cake

Öz

Bu çalışmada termiye unu ilavesi ile üretilen keklerin fizikokimyasal, tekstürel ve duyusal özellikleri üzerine olan etkileri araştırılmıştır. Keklere belirli oranlarda ilave edilen termiye unu ile keklerin protein miktarını %6,13'ten %17,50'ye kadar artırdığı tespit edilirken, keklerin özellikle kabuk renk değerlerini de artırdığı belirlenmiştir. Kek örneklerinin hem nem hem de toplam yağ miktarlarının termiye unu ilavesi ile önemli bir fark olmadığı sonucunu ortaya çıkarırken, keklerin hacminde ve karbonhidrat miktarlarında azalmaya yol açtığı tespit edilmiştir. Termiye unu ilavesi ile yapılan kek örneklerinin artan termiye unu miktarı ile kek örneklerinin tekstürel özelliklerinden esneklik, yapışkanlık, sakızımsılık, çiğnenebilirlik ve dirençlilikte azalmaya neden olurken, keklerin sertliğindeki değişiklik önemsiz bulunmuştur. Keklerin duyusal özellik parametrelerinden olan tat, yumuşaklık ve genel kabul edilebilirlik üzerine istatistiksel olarak önemli değişiklikler olduğu tespit edilmiştir. Genel olarak kek yapımında termiye unu kullanımının keklerin besin içerikleri üzerine önemli katkıları olduğu sonucuna varılmıştır.

Anahtar kelimeler: Termiye unu, Fizikokimyasal, Duyusal, Kek

1 Introduction

Lupin (*Lupinus sp.*) is a leguminous plant known for its high protein and oil content, distinguishing it as a significant genus within this plant family for its ability to thrive in marginal lands where other legumes cannot grow [1, 2].

Lupin seeds have been utilized in human nutrition and medicine for several millennia. However, over the past two decades, lupin's novel properties have been uncovered, leading to its incorporation in various functional food applications. What makes lupin valuable is its unique combination proteins, oil with desirable omega-6 to omega-3 ratios, oligosaccharides, antioxidants, fibers, and other specific components inherent to this plant. The effects of lupin components are associated with physiological conditions in the human body, including diabetes, hypertension, obesity, cardiovascular diseases, lipid concentration, glycemia, appetite, insulin resistance, and colorectal cancer. The seeds serve as alternatives to meat, egg proteins, and sausages and are used in the production of gluten-free flours, bacterial and fungal fermented products, noodles, and pasta. Lupin seed are also cooked, roasted, ground, and mixed with cereal flours in various food preparations [3].

Due to its benefits for human nutrition and health, the consumption of lupin plants and seed-derived products as food has increased in recent years [4]. Although lupin is mostly consumed as a snack in some countries, it is used globally in the production of snack foods such as biscuits, cakes, and confectioneries [5].

Cake is the third most consumed baked good after bread and biscuits, and due to its diverse methods of production and formulations, it exists in many varieties. Generally, a cake can be defined as a soft food product prepared from soft wheat flour with 8-9% protein content, sugar, oil, eggs, baking powder, water, milk, flavoring spices, nuts, and, when necessary, certain additives, then baked according to specific procedures [6-8]. The primary ingredients in cake production are flour, eggs, sugar, oil, water, milk, baking powder, surfactants, salt, and vanilla [6,9]. The quality of the cake varies based on the characteristics of the components in the formulation and the technological processes applied; the quantities and functions of the raw materials significantly

* Sorumlu yazar / Corresponding author, e-posta / e-mail: mehmetyetisen@ohu.edu.tr (M. Yetişen)
Geliş / Recieved: 06.09.2024 Kabul / Accepted: 24.09.2024 Yayımlanma / Published: 15.10.2024
doi: 10.28948/ngmuh.1544618

affect the quality of the final product and contribute to its variety [6,9,10,11].

Cake batter is an emulsion of oil in water, where solid ingredients are dispersed within the liquid phase. The interactions of all the ingredients in the batter during mixing and baking are crucial for the textural quality of the final product, particularly for achieving a high cake volume, characterized by the formation of numerous air cells within the cake, a key quality parameter. During baking, the increase in temperature induces starch gelatinization and protein denaturation; the expansion of air cells is further driven by the increased carbon dioxide production, resulting in a porous, soft, and semi-solid structure of the cake [12,13].

In light of this information, no study has been found that investigates the use of flour (powder) obtained from lupin, whose bitterness has been removed through traditional methods, and then dried, in varying proportions in cake production. This research distinguishes itself from existing literature by focusing on producing a cake that aligns with consumption habits and examining the effects of process parameters on the cake.

2 Materials and method

Lupins (*Lupinus albus*) were sourced from a local producer in the Doğanhisar district of Konya. To remove bitterness, the lupins were soaked in water at 60-70°C for 90 minutes and then left in water at room temperature for 6 days. During this soaking process to remove alkaloids, the water was changed 4-5 times [14]. The de-bittered lupin seeds were dried until they reached a moisture content of 14%. The drying process was carried out using a tray dryer (Nüve KD 200, Ankara, Turkey). The dried lupin seeds were ground into flour using a countertop kitchen grinder (Demsan, Turkey). The flour was then sifted through a 60-80 mesh sieve and stored in airtight containers in the refrigerator to protect it from air and light for analyses and production.

AACC No: 10.90.01 method was followed for cake production. In this method, the amount of wheat flour used was replaced with lupin flour by 10, 15, 20 wt %. The remaining processes were applied according to the international method. The ingredients and quantities used in cake production are given in Table 1.

2.1 *Color analysis of cake*

Color measurements for the lupin flour and cake samples were performed using a Hunter Lab Color Quest II Minolta CR-400 (Konica Minolta Sensing, Inc., Osaka, Japan) and the results were expressed as L* value [(0) black-(100) white], a* value [(+) red (-) green] and b* value [(+) yellow (-) blue] [15].

2.2 *Texture analysis*

TPA (Texture Profile Analysis) was performed on the cake samples 2 hours after baking (TA-XT Plus Texture Analyzer, UK). SMS P/35 cylindrical apparatus was used in the analysis and the test configuration was set as pre-test speed 1 mm/s, test speed 2 mm/s, post-test speed 8 mm/s, strain 10%, time 5 s, trigger force 0.049 N. In texture analysis, hardness, springiness, cohesiveness, gumminess, chewiness and resilience were measured. Cake samples were cut into 38 × 38 × 21 mm (width × depth × height) and texture analysis was performed [16].

2.3 *Proximate analysis of cake*

The moisture content of the samples was determined according to AACC 44-19 at 135°C for 2.5 hours [17]. Ash content analysis was determined according to AACC 08-01 by burning the organic compounds in the samples in a muffle furnace at 550°C [17]. Protein content analysis of the samples was performed by Kjeldahl method according to AACC 46-12. Analyses were performed on dry matter basis [17]. AACC 30-25 method was used for the determination of total oil in cake [17]. In the analysis on dry matter basis, the samples were extracted with hexane in an automatic oil extraction device (Behr, Germany), the solvent was removed and % crude oil was calculated from the amount of oil obtained. Carbohydrate values of the samples were calculated by the formula % CHO = 100 - (% moisture + % protein + % oil + % ash) [18]. The volumes of the cake samples were determined according to the principle of rapeseed replacement and the results are given in mL [19].

Table 1. Production quantities and ingredients of cakes

	Control		**A1**		**A2**		**A3**	
Ingredients	**Quantity (g)**	**%**	**Quantity (g)**	**%**	**Quantity (g)**	**%**	**Quantity (g)**	**%**
Wheat flour	60	20	30	10	15	5	0	0
Lupin flour	0	0	30	10	45	15	60	20
Sugar	80	27	80	27	80	27	80	27
Egg	60	20	60	20	60	20	60	20
Margarin	60	20	60	20	60	20	60	20
Water	35	12	35	12	35	12	35	12
Baking powder	3	1	3	1	3	1	3	1
Salt	0.5	0	0.5	0	0.5	0	0.5	0
Total	**298.5**	**100**	**298.5**	**100**	**298.5**	**100**	**298.5**	**100**

Control: 0% Lupin flour. A1: 10% Lupin flour. A2: 15% Lupin flour. A3: 20% Lupin flour.

2.4 Sensory analysis

The samples were subjected to sensory analysis by 12 people among the lecturers, master's and doctoral students at Niğde Ömer Halisdemir University, Faculty of Engineering, Department of Food Engineering. The sensory evaluation criteria for cake were appearance, taste, odor, softness, chewiness, general acceptability. The evaluations were made on a scale of 1-9 [20].

2.5 Statistical analysis

The data from three replicate experiments were analyzed through analysis of variance (ANOVA) using Minitab statistical software, version 18 (USA). The means of the main sources of variation, which exhibited statistically significant differences, were compared using the Tukey's test [21].

3 Results and discussion

The color and proximate analysis results of the cake samples are shown in Table 2 and Table 3, respectively. Crust color values can be affected by non-enzymatic reactions such as Maillard and caramelization [22]. Color measurements were taken from two different regions of the cake: the crust and the inner. The L* values of the cake crust were found to range between 49.6 and 53.55. The addition of lupin flour led to an increase in the L* values of the samples. Additionally, both the a and b values rose with the inclusion of lupin flour, and these changes were statistically significant compared to the control sample. When examining the color values of the inner parts of the cake samples, the L* value was observed to vary between 54.57 and 62.64; however, these changes were not statistically significant ($p>0.05$). Conversely, the increases in a* and b* values resulting from the addition of lupin flour were significant. Because the fractions of refined wheat flour that contain colored pigments were removed, the a* and b* color parameters were lower compared to the samples containing lupin flour [23].

In a study in which cakes were produced with different ratios of soy and lupin milk, it was reported that the color values (L* and b*) of the cakes made with lupin were higher than the color values of the cakes made with soy. [24]. When the color of the cakes made with fermented lupin powder and fermented soybean powder were examined, it was reported that the L* values of the crusts of the cakes made with lupin powder did not change. However, they stated that there was a decrease in the b* values of the crust of the cake samples. Crumb a* and b* values of FLP cake samples increased, while no change was observed in L* value [25]. In another study in which cakes were produced using lupin and pumpkin powders, an increase in a* and b* color values as well as darkness was observed in the crust and crumb regions of the samples. This increase showed that the ingredients added to the composition of the cakes affected the color formation during baking and caused darker tones in the outer and inner structure. [26].

These findings indicate that the powder has the potential to darken the overall color of the flour and give it warmer tones. In a study involving cakes prepared with fermented lupin powder, the crust color measurements of the cake samples showed L* values ranging from 47.97 to 49.24, a* values from 11.97 to 12.22, and b* values from 23.12 to 25.40. For the inner color of these cakes, the L* values were between 71.26 and 72.28, a* values ranged from -0.45 to -0.72, and b* values ranged from 27.69 to 32.17 [25].

Table 3 displays the proximate analysis results of the cake samples. In the analysis of lupin flour used as raw material in cake making, total oil content was determined as 14.67±1.68% and total protein content was determined as 47.25±0.15%. According to the data, no statistically significant differences were observed in the moisture and total oil content across the samples. Although no statistically significant difference was found among the results, the reason for the increase in the total fat content of the cakes is due to the higher fat content of lupin flour (14.67%) compared to wheat flour. This led to an increase in the total fat content as the amount of lupin flour in the formulation increased. However, in ash analysis, the A1 sample had the highest ash content (1.61%). The higher ash content of A1 may be due to the fact that at this ratio the mineral content of the lupin flour blends more effectively with the overall structure of the cake and the other ingredients.

Table 2. Color analysis of cake samples

Samples	Crust			Inner		
	L*	a*	b*	L*	a*	b*
Control	49.60±3.56^{b}	12.41±0.99^{b}	27.46±2.06^{b}	59.49±6.10^{a}	-0.64±0.38^{b}	19.13±1.58^{b}
A1	53.55±3.43^{a}	13.72±1.20^{a}	31.44±2.75^{a}	62.64±0.05^{a}	1.15±0.03^{ab}	33.06±0.12^{a}
A2	51.17±2.80^{ab}	14.97±0.25^{a}	29.42±3.23^{ab}	56.39±9.71^{a}	2.59±0.82^{a}	32.16±6.20^{ab}
A3	51.85±1.96^{ab}	14.66±0.84^{a}	30.84±1.96^{ab}	54.57±1.12^{a}	2.34±0.56^{a}	33.39±1.87^{a}

Means labeled with different letters within the same column are statistically different from each other at the $p \leq 0.05$ significance level.

Table 3. Proximate analysis results of cake samples

Samples	Moisture (%)	Ash (%)	Total Oil (%)	Volume (ml)	Protein (%)	Carbohydrate (%)
Control	11.23±1.87^{a}	1.02±0.01^{bc}	17.60±0.12^{a}	83.01±8.72^{a}	6.13±0.13^{d}	64.02±1.86^{a}
A1	10.67±0.73^{a}	1.61±0.07^{a}	20.03±1.51^{a}	68.67±6.66^{ab}	12.25±0.11^{c}	55.44±1.07^{b}
A2	8.69±0.90^{a}	0.60±0.25^{c}	23.61±4.89^{a}	59.02±6.24^{b}	14.88±0.08^{b}	52.22±2.35^{bc}
A3	11.99±2.52^{a}	1.23±0.24^{ab}	20.20±2.78^{a}	61.01±1.02^{b}	17.50±0.12^{a}	49.08±1.88^{c}

Means labeled with different letters within the same column are statistically different from each other at the $p \leq 0.05$ significance level.

So, this mineral content may give different results at lower or higher ratios. The low ash content in A2 can be explained by the fact that the increased amount of flour did not make the cake denser and homogenize the mineral distribution or interact with other ash-forming components in the cake. The cake samples' volumes ranged from 59 to 83 ml, and the addition of lupin flour reduced the sample volumes. The protein values of the cake samples ranged from 6.13% to 17.50%, and statistically significant increases in protein content were observed with the addition of lupin flour in cake production ($p \leq 0.05$). The protein content of lupin flour was determined to be 47.25% ±0.15. As a result, the use of lupin flour in different ratios increased the protein content of the cakes. It was found that the addition of lupin flour to the cake samples reduced the carbohydrate content of the samples. In the literature, it was found that the moisture content of the cakes made with fermented lupin ranged between 25.80% and 26.42%, ash content between 1.56% and 1.66%, total oil content between 19.02% and 19.98%, and protein content of the samples ranged between 10.83% and 13.20% [25]. In the cake study conducted with 5%, 10%, and 15% lupin flour ratios, the moisture, protein, ash, and oil contents were found to be in the ranges of 11.35-11.54%, 13.73-16.28%, 0.55-0.85%, and 2.04-2.87%, respectively. According to the protein, ash, and oil results, it was determined that the proportions of these components increased with the rising amount of lupin flour [27]. In another study, the protein amounts of cakes made using 45-60-75% split bean extruded flour were found to be between 8.94 and 10.28 [28]. As a result of the studies, it was determined that the protein content of protein-enriched brown rice cakes prepared using brown rice flour enriched with different levels (10%, 20%, 30%) of Bombay locust powder varied between 18.40% and 24.94% [29]. The protein levels in cakes made from the commercial mix, commercial mix supplemented with chia mucilage, new control mix, and new mix with added chia mucilage were found to be 7.74%, 7.24%, 7.56%, and 8.47%, respectively. These findings suggest that the inclusion of chia mucilage may influence the protein content of the cakes [30]. The protein values of the cake enriched with moringa leaf powder and ripe banana flour ranged between 6.57% and 8.81%, while the protein content of the cake made with 100% wheat flour was 5.79% [31]. The differences in total oil and moisture content are likely due to the different formulations used in cake making.

Texture characteristics are an important outcome for consumer acceptance of baked food products [32]. The textural characteristics of the specimens were presented in Table 4. The addition of lupin flour did not have a statistically significant effect on the hardness parameter. However, significant differences were found in the results of springiness, cohesiveness, gumminess, and chewiness. It was determined that the addition of lupin flour reduced the elasticity and stickiness properties of the cakes. In a study of biscuits made with lupin powder, the hardness and breakability of the biscuits increased with an increase in the concentration of lupin flour by ≥ 20% [33]. In another study, cakes made with almond baru flour showed greater hardness and chewiness, but reduced springiness and stickiness [34]. It was reported that the textural properties (hardness, gumminess, and chewiness) of the cake samples made by adding apple peel and apple peel pulp increased [35]. Pregelatinized sweet potato flour was produced using tumble drying method and its effects on cake and frozen cake properties were evaluated. The addition of pregelatinized sweet potato flour to wheat flour increased the hardness of the cakes [36].

The sensory analysis results of the cake samples are given in Table 5. According to the sensory analysis results, there was no statistically significant difference in the parameters of appearance, odor, and chewiness ($p>0.05$). However, decreases in taste and softness parameters were observed inversely proportional to the increased addition of lupin flour. The most preferred cake samples were A1 and A2, following the control sample. In a study on making biscuits from lupin powder, the results of sensory evaluation revealed that there was an improvement in color with the substitution of lupin flour, while taste, flavor, texture and general acceptability did not change significantly up to 20% substitution [33]. In a similar study, cake enriched with different levels of lupin flour showed no significant difference in taste, odor and overall acceptability compared to unenriched cake (control) [27]. Another study reported that incorporating fermented lupin powder at levels above 20% led to a reduction in the overall acceptability scores of the cakes [25]. Lupin cake samples were shown in Figure 1.

Figure 1. Lupin cake samples, left to right; control, A1, A2 and A3

Table 4. Texture properties of cake samples

Samples	Hardness (g)	Springiness	Cohesiveness	Gumminess	Chewiness	Resilience
Control	409.8±67.5^{a}	0.88±0.03^{a}	0.63±0.06^{a}	257.1±17.2^{a}	226.8±18^{a}	0.21±0.02^{a}
A1	343.3±69.3^{a}	0.81±0.03^{ab}	0.56±0.01^{ab}	191±42.4^{ab}	154.8±37^{ab}	0.21±0.01^{a}
A2	426.6±73.2^{a}	0.73±0.03^{bc}	0.46±0.03^{b}	195.6±29.4^{ab}	142.5±15.97^{bc}	0.19±0.01^{a}
A3	355±20.4^{a}	0.69±0.05^{c}	0.22±0.1^{c}	88.6±70.2^{b}	60.7±45.7^{c}	0.11±0.03^{b}

Means labeled with different letters within the same column are statistically different from each other at the $p \leq 0.05$ significance level.

Table 5. The results of sensory properties of cake samples

Samples	Appearance	Taste	Odor	Softness	Chewiness	General Acceptability
Control	7.75±1.06^{a}	7.67±1.44^{a}	7.17±2.08^{a}	7.58±1.24^{a}	7.33±1.30^{a}	7.58±1.51^{a}
A1	6.58±1.93^{a}	6.42±1.62^{ab}	6.5±1.24^{a}	6.92±1.44^{ab}	6.92±1.56^{a}	6.58±1.68^{ab}
A2	6.17±1.8^{a}	6.08±1.62^{ab}	6.0±1.48^{a}	5.67±1.83^{bc}	6.75±1.49^{a}	6.75±1.36^{ab}
A3	6.17±1.34^{a}	5.17±1.85^{b}	5.83±1.75^{a}	5.00±1.86^{c}	5.75±1.49^{a}	5.75±1.22^{b}

Means labeled with different letters within the same column are statistically different from each other at the p≤0.05 significance level.

4 Conclusion

In this study, lupin flour was investigated as a potential ingredient in cake production, focusing on its impact on various physicochemical and sensory attributes. The proximate analysis revealed that lupin flour significantly increased the protein content of the cakes, confirming its potential as a protein-enhancing ingredient. In the analysis of the cake samples, an increase in L*, a*, and b* values was observed in the crust, while no change was detected in the L* value of the inner. However, statistically significant increases were found in the a* and b* values of the inner. Additionally, although no significant differences were found in moisture and total oil content among the samples, the inclusion of lupin flour significantly decreased the volume of the cakes. It was concluded that there was an inverse proportion between the amount of carbohydrate and the amount of lupin flour added to the cake samples. According to the texture analysis results of the cakes, decreases were observed in springiness, cohesiveness, gumminess, chewiness and resilience parameters. However, no change was detected in the hardness value of the cakes. Sensory evaluation highlighted improvements in taste and softness parameters with increasing lupin flour content, although appearance, odor, and chewiness remained unchanged. In conclusion, the incorporation of lupin flour in cake formulations presents an opportunity to boost protein content and modify texture properties, while influencing color attributes to varying extents.

Acknowledgement

This study was supported by TUBITAK under the 2209-A University Students Research Projects Support Program with the application number 1919B012322752.

Conflict of interest

The authors declare that there is no conflict of interest.

Similarity rate (iThenticate): 17%

References

[1] T. Baytop, Türkçe bitki adları sözlüğü (No:78). Atatürk Kültür, Dil ve Tarih Yüksek Kurumu-Türk Dil Kurumu Yayınları, 1994.

[2] M. Tanur Erkoyuncu, M. Yorgancılar and E. Atalay, Farklı demir dozlarının lüpen bitkisinde fide döneminde fotosentetik verime etkisi. 11. Tarla Bitkileri Kongresi, 7-10 Eylül 2015, Çanakkale, 434-437, 2015.

[3] J. Prusinski, White lupin (*Lupinus albus* L.) nutritional and health values in human nutrition a Review. Czech Journal of Food Sciences, 35 (2), 95-105, 2017. https://doi.org/10.17221/114/2016-CJFS

[4] R. D. J. Sandoval-Muñíz, B. Vargas-Guerrero, T. J. Guzmán, P. M. GarcíaLópez, A. L. Martínez-Ayala, J. A. Domínguez-Rosales and C. M. Gurrola-Díaz, Lupin gamma conglutin protein: Effect on Slc2a2, Gck and Pdx-1 gene expression and GLUT2 levels in diabetic rats. Revista Brasileira de Farmacognosia, 28, 716-723, 2018. https://doi.org/10.1016/j.bjp.2018.08.002

[5] M. Mülayim and R. Acar, Konya'nın yöresel değeri ak acıbakla (Lüpen=Termiye) bitkisi ve kullanımı. Konya Ticaret Borsası Dergisi, 11(30), 44-49, 2008.

[6] K. Ergün, Dondurularak kurutulmuş kivi püresi tozu kullanılarak hazırlanan keklerde pişirme yöntemi ve formülasyonun kalite kriterlerine etkisinin incelenmesi, Yüksek Lisans Tezi, Ege Üniversitesi Fen Bilimleri Enstitüsü, İzmir, 2012.

[7] E. Giritlioğlu, Kinoa (*Chenopodium quinoa willd*.) ve şeker otu (*Stevia rebaudiana bertoni*) kullanılarak yeni bisküvi ve kek formülleri geliştirme üzerine bir araştırma, Yüksek Lisans Tezi, Osmaniye Korkut Ata Üniversitesi Fen Bilimleri Enstitüsü, Osmaniye, 2017.

[8] C. Topkaya, Nar kabuğu tozu ilavesinin keklerin besinsel, duyusal ve mikrobiyolojik özelliklerine etkisi, Yüksek Lisans Tezi, Pamukkale Üniversitesi Fen Bilimleri Enstitüsü, Denizli, 2017.

[9] G. Köklü, Pandispanya yapımında bazı yüzey aktif maddelerin kek nitelikleri üzerindeki etkileri, Yüksek Lisans Tezi, Çukurova Üniversitesi Fen Bilimleri Enstitüsü, Adana, 2007.

[10] İ. Ö. Gözükara, Balkabağı tozunun fizikokimyasal ve sorpsiyon özellikleri üzerine kurutma metotlarının etkisi ve balkabağı tozunun kek üretiminde kullanımı, Yüksek Lisans Tezi, İstanbul Teknik Üniversitesi Fen Bilimleri Enstitüsü, İstanbul, 2013.

[11] O. Noğay, Farklı yöntemlerle elde edilen nar çekirdek tozlarının muffin kek kalite özelliklerine etkisi, Yüksek Lisans Tezi, Pamukkale Üniversitesi Fen Bilimleri Enstitüsü, Denizli, 2014.

[12] Y. Ö. Alifakı, Nohut unu ilavesinin kekin dielektrik özelikleri ve kalite parametreleri üzerine etkisi, Yüksek Lisans Tezi, Ankara Üniversitesi Fen Bilimleri Enstitüsü, Ankara, 2013.

[13] N. Bozdoğan, Glutensiz kek formülasyonlarında hidrokolloid ve diyet lifi kullanımının hamur reolojisi ve kek kalitesi üzerine olan etkilerinin incelenmesi, Yüksek Lisans Tezi, Ege Üniversitesi Fen Bilimleri Enstitüsü, İzmir, 2015.

[14] M. Yorgancılar, E. Atalay, and M. Babaoğlu, Acılığı giderilmiş termiye tohumlarının (lüpen= *Lupinus albus*

L.) mineral içeriği, Selçuk Tarım ve Gıda Bil. Der., 23, 50, 10-15, 2009.

[15] M. Jarpa-Parra, L. Wong, W. Wismer, F. Temelli, J. Han, W. Huang and L. Chen, Quality characteristics of angel food cake and muffin using lentil protein as egg/milk replacer, International Journal of Food Science and Technology, 52(7):1604-1613, 2017. https://doi.org/10.1111/ijfs.13433

[16] C. Baltacıoğlu and M. Uyar, Kabak (*Cucubita pepo* L.) tozunun kek üretiminde potansiyel kullanımı ve kek kalite parametrelerine etkisi. Akademik Gıda, 15(3), 274-280, 2017. https://doi.org/10.24323/akademik-gida.345267

[17] AACC, 1990, American Association of Cereal Chemists, U.S.A.

[18] N. Karaağaoğlu, E. Karabudak, S. Yavuz, O. Yüksek, D. Dinçer, G. Tosunbayraktar ve H. F. Eren, Çeşitli ekmeklerin protein, yağ, nem, kül, karbonhidrat ve enerji değerleri, Gıda, 33 (1), 19-25, 2008.

[19] L. Román, A. González, T. Espina and M. Gómez, Degree of roasting of carob flour affecting the properties of gluten-free cakes and cookies. J Food Sci Technol, 54(7): 2094-2103, 2017. https://doi.org/10.1007/s13197-017-2649-x

[20] T. Ozer, M. Yetisen, C. Baltacioglu, H. Baltacioglu, H. Uslu and H. Tanguler, Use of waste fermented black carrot powder dried by different methods as a substitute in noodle production. Journal of Food Measurement and Characterization, 1-13, 2024. https://doi.org/10.1007/s11694-024-02671-y

[21] O. Düzgüneş,T. Kesici, O. Kavuncu ve F. Gürbüz, Araştırma ve deneme metotları, Ankara Üniversitesi Ziraat Fakültesi Yayınları, 1021, No:295, Ankara, 1987.

[22] R. Randhir, Y. I. Kwon and K. Shetty, Effect of thermal processing on phenolics, antioxidant activity and health-relevant functionality of select grain sprouts and seedlings. Innovative Food Science & Emerging Technologies, 9(3), 355-364, 2008. https://doi.org/10.1016/j.ifset.2007.10.004

[23] T. Cankurtaran and N. Bilgiçli, Influence of wheat milling by-products on some physical and chemical properties of filled and unfilled fresh pasta. Journal of food science and technology, 56, 2845-2854. 2019. https://doi.org/10.1007/s13197-019-03705-w

[24] M. Aslan and N. Bilgiçli, The comparison of lupin milk with soy milk as an alternative egg substitute for cake production. Journal of Food Processing and Preservation, 46(5), e16572, 2022. https://doi.org/10.1111/jfpp.16572

[25] M. Aslan and N. Bilgiçli, Improvement of functional cake formulation with fermented soy (Glycine max) and lupin (*Lupinus albus* L) powders. International Journal of Gastronomy and Food Science, 26, 100429, 2021. https://doi.org/10.1016/j.ijgfs.2021.100429

[26] T. Cankurtaran-Kömürcü & N. Bilgiçli, Improvement of nutritional properties of regular and gluten-free cakes with composite flour. Food Science and Technology International, 10820132231211929, 2023. https://doi.org/10.1177/10820132231211

[27] A. R. Ahmed, Influence of chemical properties of wheat-lupine flour blends on cake quality. American Journal of Food Science and Technology, 2(2), 67-75, 2014. https://doi.org/10.12691/ajfst-2-2-4

[28] P.Z. Bassinello, J.A.C. Bento, L.D.O.F. Gomes, M. Caliari and B.D. Oomah, Nutritional value of gluten-free rice and bean based cake mix. Ciência Rural, 50, e20190653. 2020. https://doi.org/10.1590/0103-8478cr20190653

[29] S. Indriani, M.S.B. Ab Karim, S. Nalinanon and S. Karnjanapratum, Quality characteristics of protein-enriched brown rice flour and cake affected by Bombay locust (*Patanga succincta* L.) powder fortification. Lwt, 119, 108876, 2020. https://doi.org/10.1016/j.lwt.2019.108876

[30] S. S. Fernandes, G. Filipini and M. de las Mercedes Salas-Mellado, Development of cake mix with reduced fat and high practicality by adding chia mucilage. Food Bioscience, 42, 101148, 2021. https://doi.org/10.1016/j.fbio.2021.101148

[31] R. A. Roni, M.N.H. Sani, S. Munira, M.A. Wazed and S. Siddiquee, Nutritional composition and sensory evaluation of cake fortified with moringa oleifera leaf powder and ripe banana flour. Applied Sciences, 11(18), 8474, 2021. https://doi.org/10.3390/app11188474

[32] A. Aydogdu, G. Sumnu and S. Sahin, Effects of addition of different fibers on rheological characteristics of cake batter and quality of cakes. Journal of Food Science and Technology, 55, 667-677, 2018. https://doi.org/10.1007/s13197-017-2976-y

[33] V. Jayasena and S. M. Nasar-Abbas, Effect of lupin flour incorporation on the physical characteristics of dough and biscuits. Quality Assurance and Safety of Crops & Foods, 3(3), 140-147, 2011. https://doi.org/10.1111/j.1757-837X.2011.00100.x

[34] A. F. Ramos, G.D.R.L. Mendes, R. S. Cruz, F.N. Silva, G.P. Camilloto, H. F. de Souza and I.V. Brandi, Development of cakes with almond baru flour: chemical composition and its correlations with texture profile analysis. British Food Journal, 125(4), 1206-1216, 2023. https://doi.org/10.1108/BFJ-08-2021-0866

[35] A. Hosseini, and F. Pazhouhandeh, Production of enriched cakes by apple pulp and peel powder and evaluation of chemical, functional and textural properties. Vitae, 30(1), 2023. https://doi.org/10.17533/udea.vitae.v30n1a349519

[36] S. Chittrakorn and G. C. Bora, Production of pregelatinized sweet potato flour and its effect on batter and cake properties. Journal of Food Processing and Preservation, 45(12), e16019, 2021. https://doi.org/10.1111/jfpp.16019