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Effect of buckwheat–corn flour ratios on the functional and physical properties of gluten-free crackers

Karabuğday-mısır unu oranlarının glütensiz krakerlerin fonksiyonel ve fiziksel özellikleri üzerine etkisi

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ABSTRACT

This study investigated the functional properties of gluten-free flour blends obtained by mixing buckwheat and corn flours at different ratios, as well as the physical, chemical, and visual properties of crackers produced with these blends. Functional parameters such as water holding capacity (WAC), oil absorption capacity (OAC), foaming capacity and dispersibility of flour mixtures were analyzed. While buckwheat flour stands out with its high-water retention and ash content, corn flour has different properties with its high oil absorption and light-yellow color contribution. In the obtained cracker samples, flour ratios significantly affected the quality properties of the product such as spreading rate, baking loss, color, pore structure and surface appearance. Correlation analyses and principal component analysis (PCA) results showed that there were strong relationships between the functional properties of flours and product quality. Especially the flour mixtures numbered S2 and S3 gave the most suitable results in terms of both functional and technological aspects. These findings demonstrate that selecting a buckwheat-corn flour combination in gluten-free product formulations has positive effects on product quality and provide a scientific basis for products developed with alternative grains.

Key Words: Gluten-free, cracker, flour blend ratios, functional foods, principal component analysis (PCA)

ÖZ

Bu çalışmada, karabuğday ve mısır unlarının farklı oranlarda karıştırılmasıyla elde edilen glutensiz un karışımlarının fonksiyonel özellikleri ve bu karışımlarla üretilen krakerlerin fiziksel, kimyasal ve görsel özellikleri araştırılmıştır. Un karışımlarının su tutma kapasitesi (WAC), yağ tutma kapasitesi (OAC), köpürme kapasitesi ve dağılabilirlik gibi fonksiyonel parametreleri analiz edilmiştir. Karabuğday unu yüksek su tutma ve kül içeriği ile öne çıkarken, mısır unu yüksek yağ tutma ve açık sarı renk katkısı ile farklı özellikler göstermektedir. Elde edilen kraker örneklerinde, un oranları ürünün yayılma hızı, pişirme kaybı, renk, gözenek yapısı ve yüzey görünümü gibi kalite özelliklerini önemli ölçüde etkilemiştir. Korelasyon analizleri ve temel bileşenler analizi (PCA) sonuçları, unların fonksiyonel özellikleri ile ürün kalitesi arasında güçlü ilişkiler olduğunu göstermiştir. Özellikle S2 ve S3 numaralı un karışımları hem fonksiyonel hem de teknolojik açıdan en uygun sonuçları vermiştir. Bu bulgular, glutensiz ürün formülasyonlarında doğru un kombinasyonunun seçilmesinin ürün kalitesi için kritik olduğunu göstermekte ve alternatif tahıllarla geliştirilen ürünler için bilimsel bir temel sağlamaktadır.

Anahtar Kelimeler: Glutensiz, kraker, un karışımı oranları, fonksiyonel gıdalar, temel bileşen analizi (PCA)

Introduction

The rise in the prevalence of conditions such as gluten intolerance, celiac disease, and gluten sensitivity has increased the demand for gluten-free foods (Jnawali, Kumar, & Tanwar, 2016). The development of gluten-free alternatives, particularly for traditional grain-based snacks (such as crackers), has become a critical need for both nutritional and functional benefits. Corn flour and buckwheat flour are frequently featured among gluten-free flours (Altındağ, Certel, Erem, & İlknur Konak, 2015).

Corn flour offers nutritional value due to its gluten-free content and its fiber, antioxidants, vitamin B6, thiamine, magnesium, and selenium (Dunn, Jain, & Klein, 2014). However, it is not always possible to offer technological functionality that can compete with wheat flour due to its low binding properties (Mejía-Terán, Blanco-Lizarazo, Leiva Mateus, & Sotelo-Díaz, 2024).

Buckwheat is a highly nutritious pseudocereal, a source of dietary protein with a favorable amino acid composition, trace elements, starch, vitamins, dietary fiber, and essential minerals (Filipčev et al., 2011). In snack bakery products such as biscuits and cookies, the development of a gluten network is minimal and undesirable (with the exception of hard sweet or semisweet biscuits/cookies, which are characterized by a more developed gluten network due to the low fat and sugar levels relative to flour) (Altındağ et al., 2015). Furthermore, the texture of these products is primarily attributed to starch gelatinization and supercooled sugar rather than a protein/starch structure (Gallagher, Gormley, & Arendt, 2004). Therefore, buckwheat may be a good candidate for gluten-free crackers.

Furthermore, there is significant evidence in the literature regarding the effects of flour blends on biscuit and cookie quality. For example, a study by Chauhan, Saxena, and Singh (2016) reported that diameter and spread ratio increased in cookies prepared with whole amaranth flour, while simultaneously the hardness value decreased significantly compared to the control sample. Similarly, general literature reviews reveal that the addition of amaranth flour reduces cookie hardness while increasing spreadability, thus positively affecting textural and sensory quality (Ahmed & Saeid, 2021). It has been confirmed in many studies that different flour mixtures affect the quality of the gluten-free final product (Fernandes, Vargas-Solórzano, Carvalho, & Ascheri, 2025; M. A. Mustafa, Abdallh, & Babiker, 2024; Nopa et al., 2025). These data provide strong support that similar improvements can be achieved in gluten-free biscuit or cracker formulations using different proportions of corn flour and buckwheat flour.

Considering this scientific knowledge, our study examined the techno-functional properties of corn flour and buckwheat flour blends by mixing them at five different ratios. Subsequently, physical, chemical, and sensory analyses were conducted on the gluten-free crackers produced with these blends. This study aims to demonstrate the suitability of using corn and wheat flour mixtures in cracker formulations as a gluten-free snack product, thereby contributing to the existing literature.

Material and Methods

Materials and chemicals

Corn flour (İnci, Istanbul, Türkiye) and buckwheat flour (Ipek Degirmen, Aksaray, Türkiye) were obtained from a local market. Buckwheat flour was mixed with corn flour in the ratios of 75:25, 50:50, 25:75, 0:100, and 100:0. The samples were labeled S1, S2, S3, S4, and S5, respectively. Ingredients for the crackers, including oil, salt, sugar, and baking powder, were purchased at nearby supermarkets in Kayseri, Türkiye. All other chemicals were preferred to be of analytical grade.

Methods

Water absorption capacity (WAC)

One-gram sample of each flour mixture was accurately weighed and subsequently mixed for 30 seconds with 10 milliliters of distilled water at room temperature. The flour-water suspension was left undisturbed for half an hour before centrifugation. After that, centrifugation was applied to the suspension. The centrifuge tube was cautiously opened after centrifugation, and the remaining liquid was properly decanted. After reweighing the tube, the final weight was subtracted from the initial weight to determine the WAC value, which is represented as grams of water retained per gram of flour sample (A. Adebowale, Adegoke, Sanni, Adegunwa, & Fetuga, 2012).

Oil absorption capacity (OAC)

One gram of each flour mixture was precisely weighed, and they were put into 15 mL centrifuge tubes. To guarantee homogeneity, the samples were then completely combined with 10 milliliters of refined corn oil using a vortex mixer. The samples were allowed to stand undisturbed for half an hour after the mixing process. The sample-oil combinations were centrifuged following this remaining time. The oil-flour combinations were carefully decanted into graduated cylinders when the centrifugation process was finished, and the volumes were noted (Achy, Ekissi, Kouadio, Koné, & Kouamé, 2017).

Foam capacity

The method of (R. Mustafa, He, Shim, & Reaney, 2018) was used to determine the foaming capacity of flours with some modifications. 25 mL of distilled water was first added to a graduated cylinder to analyze the foaming capacity. The samples were mixed with Ultraturax (IKA-T18, Staufen, Germany) at 11000 rpm for 1 minute. The volume of foam that resulted was measured at time 0.

Dispersibility

The foaming capability of flours was assessed using a modified version of the (AACC, 2000) method. A 25 mL measuring cylinder was filled with 5 grams of the flour sample, which had been precisely weighed. The cylinder was then filled with distilled water until the total volume reached 25 mL. To guarantee that the flour particles were evenly distributed, the mixture was vigorously mixed. The sample was then allowed to remain undisturbed for three hours. By deducting the volume of settling particles from the original 25 mL, the volume of the sample that remained in suspension was determined, and this value was used to compute dispersibility. The dispersibility of the flour sample was determined by expressing the remaining volume of the dispersed flour particles as a percentage of the overall volume.

Production of gluten-free crackers

Some modifications were made to the gluten-free cracker production method developed by (Han JeeYup, Janz, & Gerlat, 2010). First, the powder mixture was prepared. 92 g of flours S1, S2, S3, S4 and S5 were weighed separately. Sugar (3.5 g), salt (3.5 g), baking powder (0.5 g), and xanthan gum (0.5 g) were weighed and added to the flour. Then, a mixture of 20 g of sunflower oil and 45 g of water was prepared and kneaded while slowly adding it to the powder mixture. After that, the dough was kneaded for four minutes on a spotless, level surface. After the kneading process, the dough was rolled out in a rolling machine to thickness of 3 mm and width of 20x20 mm (Rondo Doge, Switzerland) and shaped using the stamp cutting technique. Then, the dough shapes were created, and they were put on baking trays that had been oiled and baked at 180°C in a preheated oven for 25 min. After cooking, the crackers were covered with wax paper and allowed to cool at room temperature. The cooled products were then stored at -20°C until analysis.

Spread ratio

A composition bar was used to measure the thickness and diameter of each cracker at three different locations. According to (Chauhan, Saxena, & Singh, 2015), the spreading ratio was then computed by averaging the observations made at each location.

Baking loss

To obtain the baking loss (%), calculations were made by taking Wf, the weight of the baked crackers after cooling to room temperature, and Wi, the weight of the dough before baking (Grossi

Bovi Karatay, Rebellato, Joy Steel, & Dupas Hubinger, 2022).

Moisture and ash content

Three grams of the variously made crackers were put in an oven (IN 160Plus Memmert, Germany) and dried for three hours at 105 °C (Grossi Bovi Karatay et al., 2022). After carefully weighing 0.3 g cracker samples into a porcelain crucible, they were burned to 600 °C in a muffle furnace that had been warmed and maintained there until white or gray ash was produced (Doner & Ege, 2004).

Statistical analysis

For statistical analysis, MINITAB for Windows (Minitab v19.1.1 software, Minitab Ltd., Coventry, UK) was used. The normality assumption of ANOVA was ensured by the normality test. Fisher's LSD test was used after a one-way analysis of variance to find significant differences between the mean values. Additionally, XLSTAT Software (XLSTAT, USA) was used to perform principal component analysis (PCA), which groups variables according to their similarities in order to reduce the dimensionality of the data. Pearson correlation test was conducted for comparisons of data.

Results and Discussion

Water absorption capacity (WAC)

WAC values of flour mixtures are given in Figure 1. Low water binding is ascribed to an intimate connection of starch polymers in the native granule, while WAC gives information on the strength of the starch intergranular link (Soni & Sharma, 1987; Zhang et al., 2024). The WAC value of 100% whole corn flour from the prepared flour mixtures was approximately 2.44 ± 0.04 g/g, which is similar to the value reported for Advanta whole corn flour by (Mejía-Terán et al., 2024). The WAC value of 100% buckwheat flour was found to be 2.41 ± 0.06 g/g. (Yu et al., 2018) reported the WAC value of buckwheat flour milled with a stone mill as 1.28 g/g. Variable buckwheat flours may exhibit variable WAC values, which can be attributed to variations in the amounts of damaged starch in each sample (Yu et al., 2018). WAC values of the blended flours were found to be 2.44, 1.94, and 2.35 for S1, S2, and S3, respectively. The difference between WAC values for all flour mixtures is statistically insignificant ($p>0.05$).

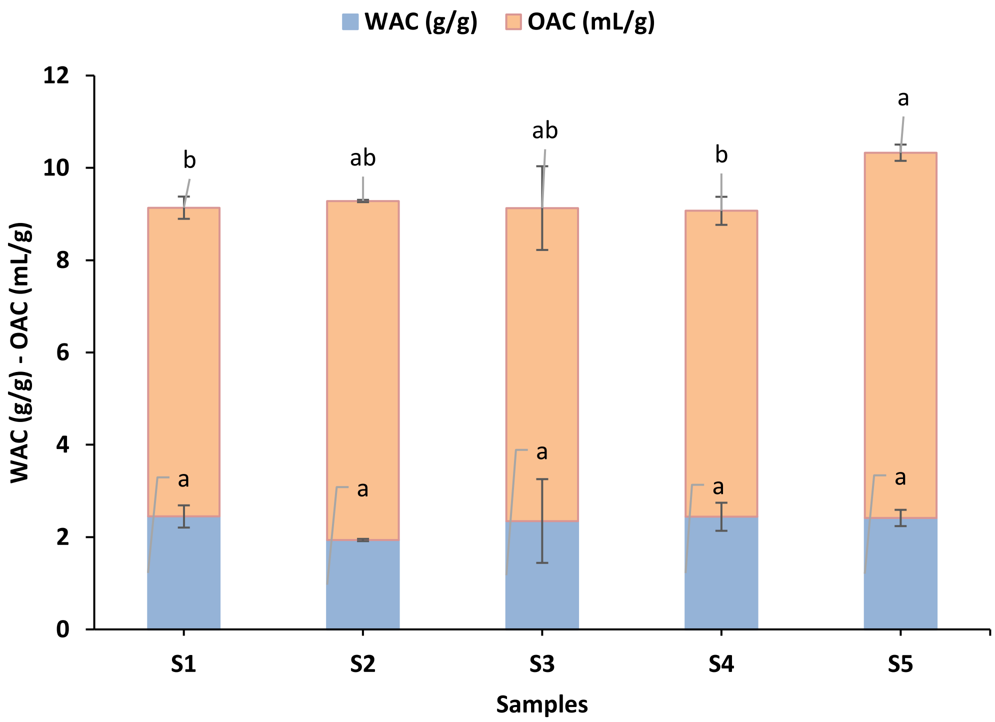

Figure 1. Water and oil absorption capacity of composite flours

* Significant differences ($p < 0.05$) between means are indicated by [a-b].

Oil absorption capacity (OAC)

OAC is a crucial functional characteristic and its basic mechanism of OAC is mainly due to the physical retention of fat through capillary attraction (Kinsella, 1976; Wang, Maximiuk, Fenn, Nickerson, & Hou, 2020). The highest OAC was measured as 7.91±0.18 mL/g in 100% buckwheat flour. Food products that absorb oil have better mouthfeel and flavor retention. The increased ability to absorb oil indicates that the ingredients in flour are lipophilic (Ubbor & Akobundu, 2009). For corn flour, OAC is 6.62±0.30 mL/g. The OAC of composite flour samples was found to be 6.68±0.24, 7.34±0.03, and 6.77±0.90 for S1, S2, and S3, respectively (Figure 1). The variance in OAC is caused by the chain length distribution and the amylose/amylopectin ratio (Klunklin & Savage, 2018). According to research findings, there is no difference between the OAC values of the flour blends ($p>0.05$), but the OAC value of corn flour is statistically different from the others ($p<0.05$). A flour sample with a higher OAC value may contain a higher proportion of non-polar side chains in its protein molecules (Poshadri et al., 2023).

Foaming capacity

Protein-formed interfacial films, which keep air bubbles suspended and slow down the rate of coalescence, are often responsible for foaming capacity and stability (Du, Jiang, Yu, & Jane, 2014). The proteins and certain other ingredients, including carbohydrates, that are included in the flours determine their foaming qualities (Sreerama, Sashikala, Pratape, & Singh, 2012). The foaming capacities of composite flours differed from each other (Figure 2). When samples S2, S3 and S4 are examined, it can be said that the foam capacity decreases as the buckwheat ratio decreases and the corn flour ratio increases. The amount of foaming was significantly impacted by the concentrations of the flours in solution. Similarly, it has been reported that the foaming capacity of flours prepared from blends of wheat, rice, and gram flour varies depending on the flour ratio (Kakar et al., 2022). The foaming capacity of legume flours prepared at different concentrations varied depending on the concentration (K. Adebowale & Lawal, 2003; Du et al., 2014). Protein in the dispersion has been consistently responsible for the formation of a continuous, cohesive layer surrounding the air bubbles in the foam, which can lower the surface tension at the water-air interface (Kaushal, Kumar, & Sharma, 2012).

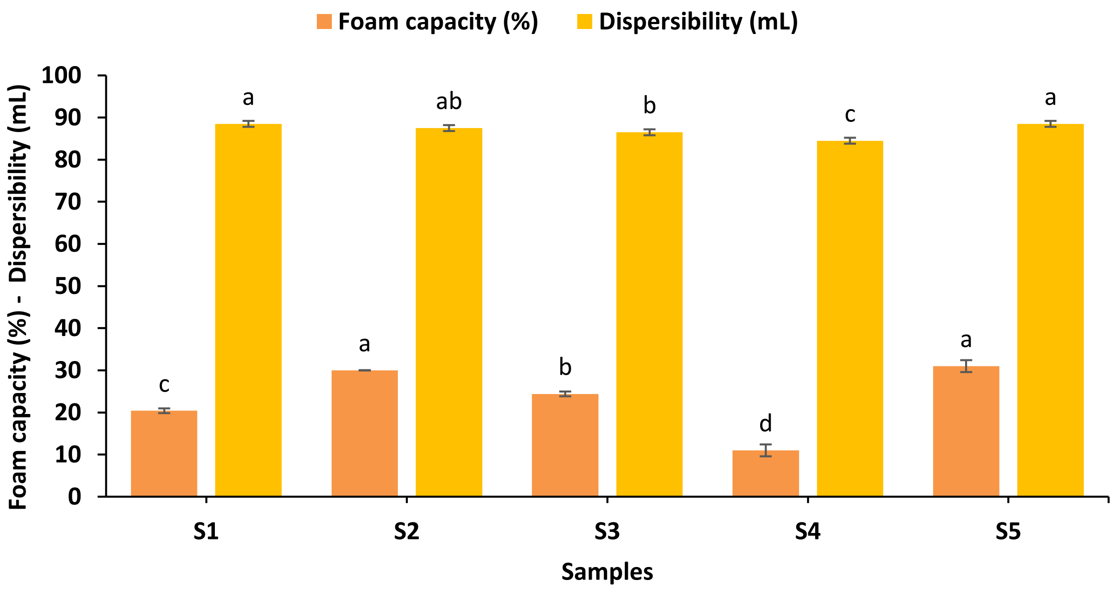

Figure 2. Foam capacity and dispersibility of composite flours

* Significant differences ($p < 0.05$) between means are indicated by $^{a-b}$.

Dispersibility

Dispersibility is a feature that reveals the hydrophobic action of flour and controls its propensity to separate from water molecules (Joy & Ledogo, 2016). Dispersibility of composite flours ranged from 84.50% - 88.50% with sample S4 as the lowest and sample S1 and S5 as the highest (Figure 2). The ability of flour to reconstitute in water is measured by its dispersibility. When moistened, flour with a higher dispersibility reconstitutes effectively (Adeyeye & Akingbala, 2015). The results obtained from the present study showed that there were significant differences ($p<0.05$) in the dispersibility of flour samples as a result of different proportions of buckwheat and corn flour mixtures. All of the flour samples' strong dispersibility scores, however, suggest that they will swiftly reconstitute into a finely textured paste (Mubaiwa, Fogliano, Chidewe, & Linnemann, 2018).

Cracker analysis

Apparent differences in the visual characteristics of gluten-free crackers were observed among samples containing different ratios of buckwheat and corn flour (Figure 3). As the proportion of buckwheat flour increased, the color of the crackers shifted to darker tones, while as the proportion of corn flour increased, products with a lighter yellow color were obtained (as typically seen in sample S4).

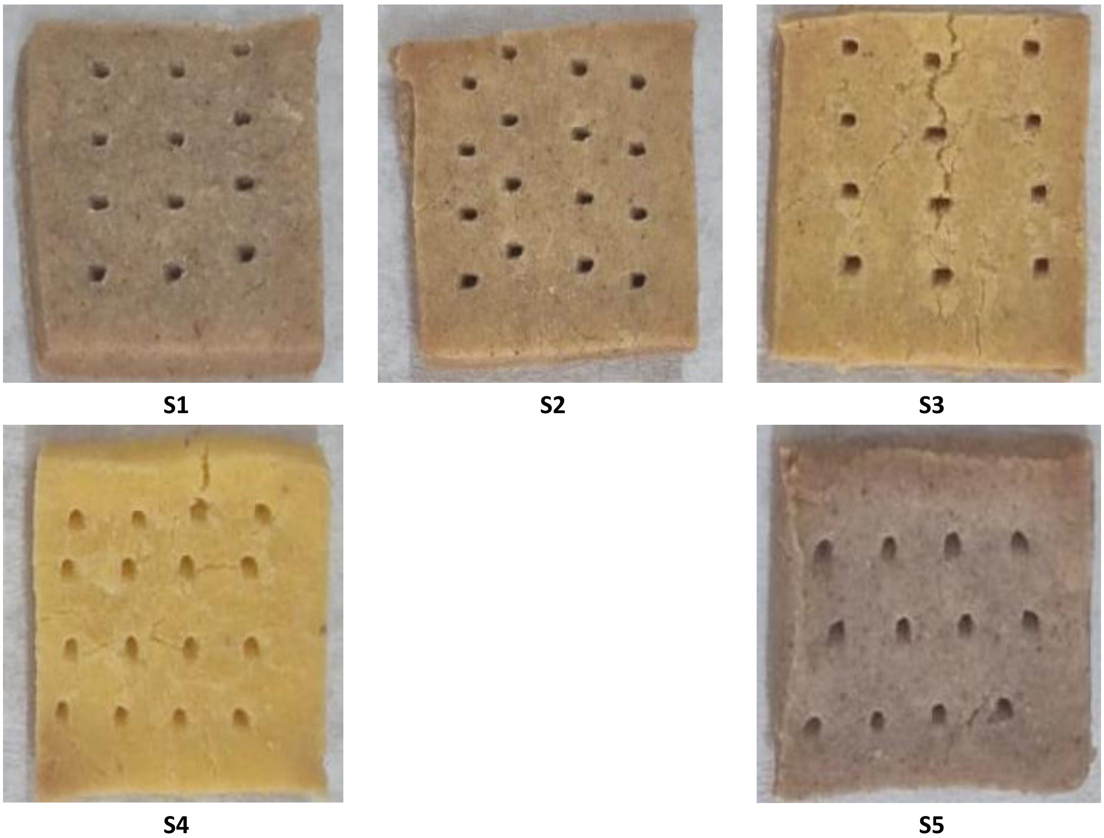

Figure 3. The images of crackers

In addition, the change in flour composition affected the distribution of pores and surface structure. While a denser and more compact structure was observed in samples with a high buckwheat content (S1, S5), crackers with a more homogeneous surface, lighter color and more regular pore distribution were formed in samples with a high corn flour content (S3, S4). The medium ratio mixture (S2) exhibited a visual appearance in which the properties of the two flour types were balanced. These findings indicate that flour composition has a significant effect on the color, pore structure and overall appearance of crackers.

Significant differences were observed between the spread ratio and baking loss values in gluten-free crackers produced with different proportions of buckwheat and corn flour blends ($p<0.05$). The highest spread ratio was obtained in sample S3, which can be partially explained by the balance between the starch content of corn flour and the water-binding capacity of buckwheat flour. Similarly, the literature report that starch-rich flours such as corn starch with tapioca and corn resistant starch, preparations tend to swell and spread more than gluten-free products (Korus, Witczak, Ziobro, & Juszczak, 2009).

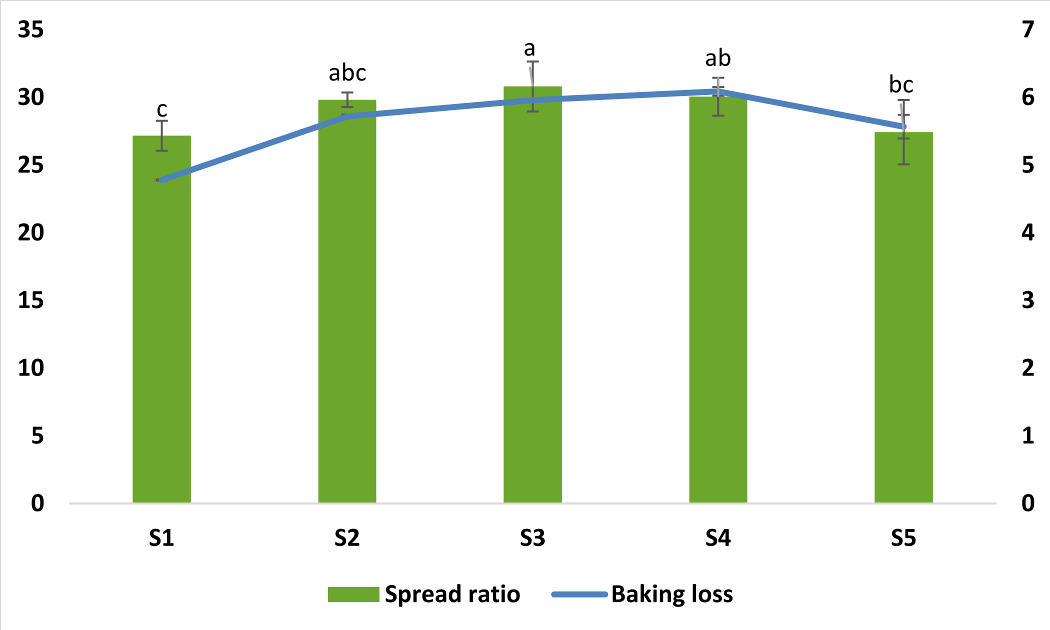

Figure 4. The spread ratio and baking loss values of the prepared crackers

* Significant differences ($p < 0.05$) between means are indicated by [a-b].

When baking loss values were examined, it was observed that the loss increased slightly as the corn flour ratio increased. This may be due to the lower water-holding capacity of the protein structure of corn flour compared to buckwheat. Buckwheat flour, due to its high content of soluble dietary fiber and protein, strengthens the matrix structure of the product and limits baking loss (Baljeet, Ritika, & Roshan, 2010).

Generally, optimum values for both spreading ratio and baking loss were achieved when buckwheat and corn flour were mixed in specific proportions (especially in samples S2 and S3). These results demonstrate that flour combinations are decisive for technological properties in gluten-free formulations and are consistent with similar findings in the literature (Fiorda, Soares Jr, da Silva, de Moura, & Grossmann, 2015; Ragaee, Abdel-Aal, & Noaman, 2006).

The relationships between the techno-functional properties of the flours and the physical and chemical parameters of the crackers were evaluated using correlation analysis and PCA. The correlation matrix revealed a strong positive correlation between oil absorption capacity (OAC) and foam capacity ($r^2=0.812$) and dispersibility (Table 1). Similarly, the correlation between foam capacity and dispersibility was also high ($r^2=0.747$). These results show that the surface properties and hydrophilic-lipophilic balance of flours together affect the functional behavior of the product.

Table 1. Correlation matrices between the parameters (Pearson)

Variables	WAC	OAC	Foam capacity	Dispersibility	Spread ratio	Baking loss	Moisture content	Ash
WAC	**1**	-0.285	-0.520	-0.120	-0.364	-0.190	0.048	0.507
OAC	-0.285	**1**	**0.812**	0.565	-0.382	-0.001	0.046	0.307
Foam capacity	-0.520	**0.812**	**1**	0.747	-0.226	-0.161	-0.258	-0.133
Dispersibility	-0.120	0.565	0.747	**1**	-0.748	-0.766	0.160	-0.377
Spread ratio	-0.364	-0.382	-0.226	-0.748	**1**	**0.831**	-0.616	0.094
Baking loss	-0.190	-0.001	-0.161	-0.766	**0.831**	**1**	-0.496	0.579
Moisture content	0.048	0.046	-0.258	0.160	-0.616	-0.496	**1**	-0.232
Ash	0.507	0.307	-0.133	-0.377	0.094	0.579	-0.232	**1**

Values in bold are different from 0 with a significance level alpha=0,1

On the other hand, a significant negative relationship was found between the spread ratio and dispersibility (r^2=-0.748) and baking loss (r^2=-0.766). In other words, crackers made from highly dispersible flour blends had lower spread ratio and more limited baking loss. Conversely, a strong positive correlation was found between spread ratio and baking loss (r^2=0.831). This suggests that crackers with greater spread also experience greater mass loss.

While moisture content was negatively correlated with spreading rate and baking loss, a positive correlation was found between ash content and baking loss. This result suggests that formulations with higher mineral content were prone to greater mass loss during baking. Eigenvalues, variability and cumulative variability data were given in Table 2.

Table 2. Eigenvalues, variability and cumulative variability

	F1	F2	F3	F4
Eigenvalue	3,385	2,207	1,589	0,819
Variability (%)	42,318	27,583	19,862	10,237
Cumulative %	42,318	69,901	89,763	100,000

Table 3 shows the PCA factor loadings. According to this table, the relationships between the techno-functional properties of flours and the quality parameters of crackers were revealed.

Table 3. Factor loadings of principal component analysis

	F1	F2	F3
WAC	-0.137	-0.664	0.640
OAC	0.546	0.624	0.480
Foam capacity	0.628	0.768	0.051
Dispersibility	0.958	0.150	0.036
Spread ratio	-0.843	0.411	-0.346
Baking loss	-0.825	0.490	0.164
Moisture content	0.434	-0.583	-0.051
Ash	-0.421	0.127	0.892

*WAC: water absorption capacity, OAC: oil absorption capacity

The first component (F1) loaded positively with dispersibility and negatively with spreading rate and baking loss, indicating that flours with higher dispersibility were associated with lower spreading and loss values. The second component (F2) was found to be positively correlated with foaming capacity and oil absorption capacity, revealing that the surface properties of flours have an effect on the spreading and baking behavior of the product. The third component

(F3) was strongly loaded with ash content and water-binding capacity, supporting that mineral-rich flours also have higher water-binding capacity. The fourth component (F4) revealed moisture content as a distinguishing factor. In general, PCA results showed that buckwheat flour had a higher correlation coefficient in ash and water holding capacity analyses, while corn flour had a higher correlation coefficient with foaming capacity and spread ratio.

The plot of the component loading vectors of the variables obtained from PCA was presented in Figure 5. As a result of PCA, the first component (F1) explains 42.32% of the total variance, the second component (F2) explains 27.58%, and both components together represent 69.90% of the total variance in the dataset. In the variables graph, the direction and length of the vectors show the correlation level of these variables with the relevant components.

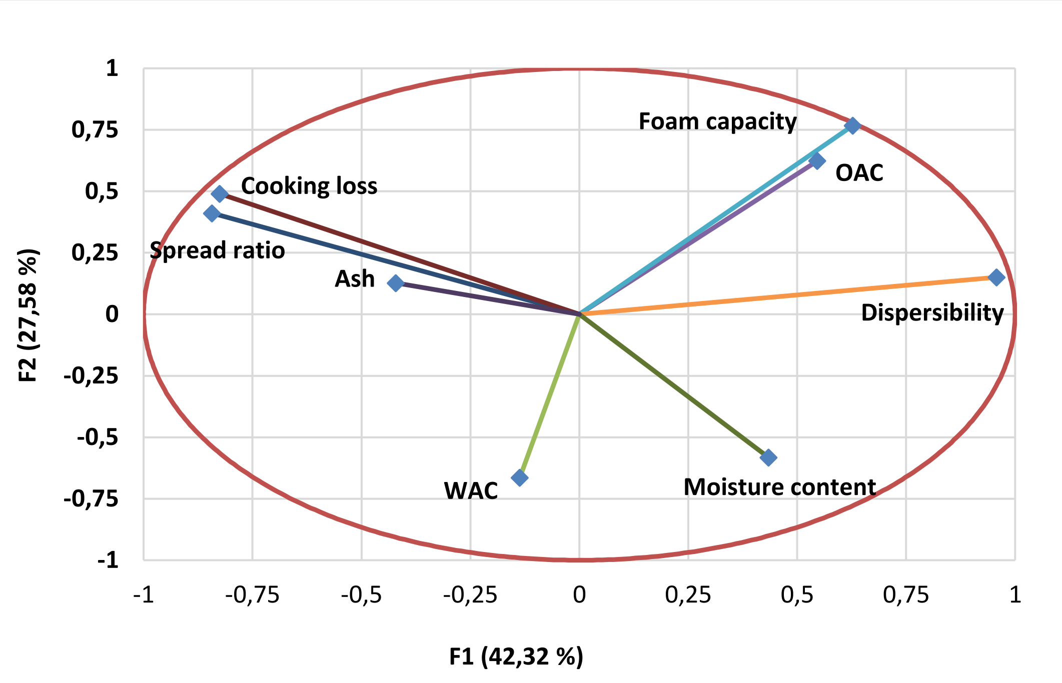

Figure 5. The plot of the component loading vectors of the variables

According to the analysis results, dispersibility, oil absorption capacity (OAC) and foaming capacity were in a similar direction and show a high positive correlation with the F1 component. This suggests that these three properties tend to increase together and are represented by the same principal component. On the other hand, the moisture content and water absorption capacity (WAC) variables are in the opposite direction of this group, indicating a negative correlation with dispersibility. These findings suggest that increasing moisture content and WAC values may negatively affect dispersibility.

Additionally, properties such as baking loss and spreading rate had higher reflectance in the direction of the second component (F2) and were positively correlated with it. Ash content, on the other hand, showed a low correlation with both components and is located near the center point. This indicates that the relationships between ash content and other variables evaluated were weak.

Overall, the PCA results revealed that functional properties were highly correlated with some physical and chemical properties, indicating that the combined evaluation of these parameters might provide important information for optimizing product properties.

Conclusion

In this study, the functional properties of gluten-free flour mixtures obtained by mixing buckwheat and corn flours at different ratios and the physical, chemical and visual properties of crackers produced from these mixtures were evaluated comprehensively. The results revealed that flour mixing ratios significantly affected functional properties such as water and oil holding capacity, foaming capacity and dispersibility. While buckwheat flour stands out with its high water retention capacity, mineral (ash) content and dark color contribution, corn flour contributed with its high oil absorption capacity, light yellow color and better spreading behavior. As the buckwheat ratio increases in the cracker samples, darker colored, more compact and dense structure is obtained; as the corn ratio increases, lighter colored, homogeneous pore distribution and crispier products are obtained. Furthermore, it was determined that technological properties such as spreading rate and baking loss are inversely proportional to dispersibility and directly proportional to each other. These findings demonstrate that the surface properties and water/oil retention capacity of flours play an important role in determining product performance. Correlation and principal component analyses (PCA) revealed strong relationships between the functional properties of the flours and the technological performance of the crackers. Particularly, the flour mixtures numbered S2 and S3 provided balanced and desired product quality in terms of both functional and sensory aspects. Overall, this study demonstrates that selecting the right flour combinations in the gluten-free product development process is crucial for product quality, consumer acceptance, and technological suitability. The data obtained can contribute to product development studies for both functional food production and special nutritional requirements.

Conflict of Interest

The authors declared no potential conflicts of interest regarding the publication of this article.

Author's Contributions

Duygu ASLAN TÜRKER and Elif Meltem İŞÇİMEN was responsible for selection of the research topic, conducting experiments, data collections and analysis, writing and reviewing the manuscript

References

AACC, A. M. (2000). American association of cereal chemists. *Method 66–50, 26–10A, 26.41, 66, 41*.

Achy, J. Y., Ekissi, G. S. E., Kouadio, P., Koné, F. M. T., & Kouamé, L. P. (2017). Effect of boiling and baking times on the functional properties of aerial yam (Dioscorea bulbifera) flours cv Dugu-won harvested in Côte d'Ivoire. *International Journal of Agronomy and Agricultural Research, 10*(2), 1-12.

Adebowale, A., Adegoke, M., Sanni, S., Adegunwa, M. O., & Fetuga, G. (2012). Functional properties and biscuit making potentials of sorghum-wheat flour composite.

Adebowale, K., & Lawal, O. (2003). Foaming, gelation and electrophoretic characteristics of mucuna bean (Mucuna pruriens) protein concentrates. *Food Chemistry, 83*(2), 237-246.

Adeyeye, S. A., & Akingbala, J. O. (2015). Physico-chemical and functional properties of cookies produced from sweet potato-maize flour blends. *Food Science and Quality Management, 43*, 48-57.

Ahmed, M., & Saeid, A. (2021). A Review on Effects of Pseudo Cereals Flour on Quality Properties of Biscuit, Cookies and Cake. In A. Novo Barros & I. Gouvinhas (Eds.), *Innovation in the Food Sector Through the Valorization of Food and Agro-Food By-Products*. Rijeka: IntechOpen.

Altındağ, G., Certel, M., Erem, F., & İlknur Konak, Ü. (2015). Quality characteristics of gluten-free cookies made of buckwheat, corn, and rice flour with/without transglutaminase. *Food Science and Technology International, 21*(3), 213-220.

Baljeet, S., Ritika, B., & Roshan, L. (2010). Studies on functional properties and incorporation of buckwheat flour for biscuit making. *International food research journal, 17*(4).

Chauhan, A., Saxena, D., & Singh, S. (2015). Total dietary fibre and antioxidant activity of gluten free cookies made from raw and germinated amaranth (Amaranthus spp.) flour. *LWT-Food Science and Technology, 63*(2), 939-945.

Chauhan, A., Saxena, D. C., & Singh, S. (2016). Physical, textural, and sensory characteristics of wheat and amaranth flour blend cookies. *Cogent Food & Agriculture, 2*(1), 1125773. doi:10.1080/23311932.2015.1125773

Doner, G., & Ege, A. (2004). Evaluation of digestion procedures for the determination of iron and zinc in biscuits by flame atomic absorption spectrometry. *Analytica Chimica Acta, 520*(1), 217-222. doi:https://doi.org/10.1016/j.aca.2004.05.069

Du, S.-k., Jiang, H., Yu, X., & Jane, J.-l. (2014). Physicochemical and functional properties of whole legume flour. *LWT - Food Science and Technology, 55*(1), 308-313. doi:https://doi.org/10.1016/j.lwt.2013.06.001

Dunn, M. L., Jain, V., & Klein, B. P. (2014). Stability of key micronutrients added to fortified maize flours and corn meal. *Annals of the New York Academy of Sciences, 1312*(1), 15-25. doi:https://doi.org/10.1111/nyas.12310

Fernandes, S. d. S., Vargas-Solórzano, J. W., Carvalho, C. W. P., & Ascheri, J. L. R. (2025). Innovative Gluten-Free Fusilli Noodle Formulation: Leveraging Extruded Japanese Rice and Chickpea Flours. *Foods, 14*(14), 2524.

Filipčev, B., Šimurina, O., Sakač, M., Sedej, I., Jovanov, P., Pestorić, M., & Bodroža-Solarov, M. (2011). Feasibility of use of buckwheat flour as an ingredient in ginger nut biscuit formulation. *Food Chemistry, 125*(1), 164-170.

Fiorda, F. A., Soares Jr, M. S., da Silva, F. A., de Moura, C. M. A., & Grossmann, M. V. E. (2015). Physical quality of snacks and technological properties of pre-gelatinized flours formulated with cassava starch and dehydrated cassava bagasse as a function of extrusion variables. *LWT-Food science and technology, 62*(2), 1112-1119.

Gallagher, E., Gormley, T. R., & Arendt, E. K. (2004). Recent advances in the formulation of gluten-free cereal-based products. *Trends in Food Science & Technology, 15*(3-4), 143-152.

Grossi Bovi Karatay, G., Rebellato, A. P., Joy Steel, C., & Dupas Hubinger, M. (2022). Chickpea aquafaba-based emulsions as a fat replacer in pound cake: Impact on cake properties and sensory analysis. *Foods, 11*(16), 2484.

Han JeeYup, H. J., Janz, J., & Gerlat, M. (2010). Development of gluten-free cracker snacks using pulse flours and fractions.

Jnawali, P., Kumar, V., & Tanwar, B. (2016). Celiac disease: Overview and considerations for development of gluten-free foods. *Food Science and Human Wellness, 5*(4), 169-176. doi:https://doi.org/10.1016/j.fshw.2016.09.003

Joy, E.-E., & Ledogo, N. (2016). The effect of variety and processing methods on the functional and chemical properties of rice flour. *International Journal of Nutrition and Food Sciences, 5*(1), 80-84.

Kakar, A., Miano, T. F., Soomro, A. H., Yar, A., Memon, S. A., & Khan, B. (2022). Oil and water absorption capacity of wheat, rice and gram flour powders. *International Journal of Ecosystems & Ecology Sciences, 12*(2).

Kaushal, P., Kumar, V., & Sharma, H. (2012). Comparative study of physicochemical, functional, antinutritional and pasting properties of taro (Colocasia esculenta), rice (Oryza sativa) flour, pigeonpea (Cajanus cajan) flour and their blends. *LWT-Food Science and Technology, 48*(1), 59-68.

Kinsella, J. (1976). Functional properties of food proteins: a review. *Critical Reviews in Food Science and Nutrition, 7*(2), 219-280.

Klunklin, W., & Savage, G. (2018). Physicochemical, antioxidant properties and in vitro digestibility of wheat–purple rice flour mixtures. *International Journal of Food Science and Technology, 53*(8), 1962-1971.