

## Uses of Probiotic Sources to Decrease the Phytic Acid Content of Chickpea\*

Nohutun Fitik Asit İçeriğini Azaltmak Amacıyla Probiyotik Kaynaklarının Kullanımı

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### Abstract

Soaking is a common household practice used to improve the cooking quality and digestibility of legumes; however, its effect on phytic acid, a major antinutritional factor, varies depending on the soaking medium. This study investigated the impact of soaking chickpeas in some liquids—kefir, pickle juice, and their water-based mixtures—on phytic acid content and selected chemical and color properties. Chickpea samples were soaked for 24 or 48 hours in five different liquids, and phytic acid, moisture, ash, protein, fat, and color (L\*, a\*, b\*) values were determined. Kefir and pickle juice were selected due to their probiotic content, which is believed to contribute to the breakdown of phytic acid. The initial phytic acid content of unsoaked chickpeas was 757.98 mg/100 g. Soaking significantly reduced phytic acid levels in all treatments (p<0.01), with kefir showing the strongest effect, lowering the value to 514.08 mg/100 g. Extending the soaking duration further enhanced the reduction, resulting in an average decrease of approximately 43% after 48 hours. This indicated that probiotic sources can reduce the phytic acid content in legumes when used as soaking liquid. Soaking also caused significant changes in moisture, ash, and fat contents, while color parameters were influenced by both the type of soaking liquid and the duration. These findings indicate that probiotic sources, particularly kefir, may enhance phytate breakdown during soaking, potentially improving the mineral bioavailability of chickpeas. This practical approach can be easily applied in household cooking and may guide the development of nutritionally improved legume-based products. The lack of direct microbial enumeration and the use of a single chickpea variety are acknowledged as limitations and are discussed in the manuscript.

**Keywords:** Chickpea, Phytic acid, Soaking, Probiotics, Kefir, Pickle juice

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## Öz

Baklagillerin pişirme kalitesini ve sindirilebilirliğini artırmak için yaygın olarak kullanılan bir ev uygulaması olan ıslatma işlemi, bekletme ortamına bağlı olarak, önemli bir antibesinsel faktör olan fitik asitin miktarının azaltılması üzerinde etkilidir. Bu çalışmada, nohutun probiyotik açısından zengin sıvılarda (kefir, turşu suyu ve bunların su bazlı karışımları) bekletilmesinin fitik asit içeriği ve seçilmiş kimyasal ve renk özellikleri üzerindeki etkisi araştırılmıştır. Nohut örnekleri beş farklı sıvıda 24 veya 48 saat bekletilmiş ve fitik asit, nem, kül, protein, yağ ve renk ( $L^*$ ,  $a^*$ ,  $b^*$ ) değerleri belirlenmiştir. Kefir ve turşu suyu probiyotik mikroorganizma içerikleri nedeniyle seçilmiş olup bu probiyotiklerin fitik asidin parçalanmasına katkıda bulunduğu düşünülmektedir. Islatma öncesi nohut örneklerinin fitik asit içeriği 757,98 mg/100 g olarak tespit edilmiştir. Islatma işlemi tüm uygulamalarda örneklerin fitik asit seviyelerini önemli ölçüde azaltmış ( $p<0.01$ ) olup, kefir ise en güçlü etkiyi göstererek değeri 514,08 mg/100 g'a kadar düşürmüştür. Bekleme süresinin uzatılması, fitik asitteki azalmayı daha da artırmış ve 48 saat bekletme sonrası fitik asitte ortalama %43 oranında bir azalma sağlanmıştır. Bu durum, probiyotik kaynakların ıslatma sıvısı olarak kullanıldığında baklagillerdeki fitik asit içeriğini azaltabileceğini göstermiştir. Islatma işlemi ayrıca nem, kül ve yağ içeriğinde önemli değişikliklere neden olurken, renk parametreleri hem ıslatma sıvısının türünden hem de süresinden etkilenmiştir. Bu bulgular, probiyotik kaynakların, özellikle kefirin, ıslatma sırasında fitat parçalanmasını arttırabileceğini ve potansiyel olarak nohutun mineral biyoyararlılığını iyileştirebileceğini göstermektedir. Bu pratik yaklaşım, ev yemeklerinde kolaylıkla uygulanabilir ve besin değeri artırılmış baklagil bazlı ürünlerin geliştirilmesine rehberlik edebilir. Doğrudan mikrobiyal sayım yapılmaması ve tek bir nohut çeşidinin kullanılması, sınırlamalar olarak kabul edilmekte ve makalede tartışılmaktadır.

**Anahtar Kelimeler:** Nohut, Fitik asit, Suda bekletme, Probiotikler, Kefir, Turşu suyu

## 1. Introduction

Belonging to the Leguminosae family, legumes are widely acknowledged for their high nutritional value and their contribution to the formulation of various food products (Atudorei et al., 2021; Yaver and Bilgiçli, 2021; Sahni and Sharma, 2023; Joshi et al., 2024; Huamaní-Perales et al., 2024). Despite being present in varying amounts based on the type, legumes contain some compounds that are hard to digest and cause gas in the gastrointestinal tract (Abdel-Gawad, 1993; Banti and Bajo, 2020). Reducing the antinutritional compounds contained in legumes is considered important to improving their bioavailability (Habiba, 2002). Phytic acid serves as a significant phosphorus reservoir in plant tissues, particularly in cereal grains and legumes (Harland and Narula, 1999; Kumar et al., 2023). However, its chemical structure enables strong binding with essential dietary minerals such as iron, zinc, and calcium, forming insoluble complexes that limit their intestinal absorption. These chelating interactions interfere with mineral ionization, which is critical for bioavailability, thereby reducing the nutritional quality of legume-based foods (Lopez et al., 2002). Phytic acid, having a strong potential to form complexes, not only reduces the absorption of minerals in the gut, but also prevents the digestion of proteins (Oatway et al., 2001). Phytate forms insoluble complexes with iron, zinc and calcium, thereby markedly reducing their intestinal absorption and bioavailability. This interaction is of particular importance in populations consuming legume-based diets, where phytate-mineral complexes can lead to micronutrient deficiencies. Therefore, reducing phytic acid is a critical step toward improving the nutritional quality and mineral accessibility of chickpeas and other legumes.

Several culinary and processing techniques have been explored to mitigate phytic acid content in legumes and grains. These include heat treatments such as cooking (Corzo-Ríos et al., 2020) and autoclaving (Vijayakumari et al., 1996) biological methods like germination (Khalil and Mansour, 1995) and fermentation (Liang et al., 2008), and mechanical operations like peeling (Ghavidel and Prakash, 2007). Among these, water soaking (Khattab and Arntfield, 2009) stands out as a simple and commonly practiced method, not only reducing anti-nutritional compounds but also improving texture and cooking efficiency. Soluble anti-nutritional compounds in the grain can be lessened with the help of soaking (Abd El-Hady and Habiba, 2003; Sharma and Sarkar, 2023). Furthermore, the temperature of the soaking water and the duration of the soaking facilitate the degradation of phytates (Albarracín et al., 2013). In a study it was found that soaking in water for 12 hours reduced the phytic acid content of some legumes, including chickpeas, by 7.0-15% (Mehanni et al., 2021). In another study, soaked faba beans at different temperatures and in water with different contents and found that more than half of the phytic acid was removed in samples kept for 12 hours under acidic conditions at 37 °C (Cheng et al., 2023).

Although the traditional practice requires legumes to be soaked in water before cooking, whether liquids with different properties may yield more effective results is a matter to be researched and discussed. In this respect, the liquids that stand out are those characterized by high probiotic content. Fermented food products, including kefir and pickle juice, are rich in beneficial microbial cultures, particularly lactic acid bacteria (Ramos et al., 2013; Menezes et al., 2020; Ahire et al., 2021). These microorganisms have been shown to possess enzymatic capabilities, such as phytase production, which can hydrolyze phytic acid molecules (Andrabi et al., 2016). The activity of phytase enhances mineral bioavailability and has attracted attention for its potential in improving the nutritional profile of legume-based meals through natural, food-grade interventions. These bacteria can produce both intracellular phytase and extracellular phytase (Sharma et al., 2020). Several research have been conducted on the use of lactic acid bacteria, a kind of probiotics, to enhance the nutritional attributes of food. Ghamry et al. (2023) showed that *Lactobacillus apis* and *Lactobacillus plantarum* fermentations had a higher effect on the degradation of phytate in wheat bran compared to *Saccharomyces cerevisiae* fermentation and reported that *Lactobacillus apis* has a significant potential in improving the nutritional properties of cereal products and reducing the amount of antinutritional compounds in these products. Reale et al. (2004) examined the phytase activity of strains of *Lactobacillus plantarum*, *Lactobacillus brevis*, *Lactobacillus curvatus*, and *Saccharomyces cerevisiae*. It was observed that 80–90% of myo-inositol hexaphosphate is digested by the phytase activity of lactic acid bacteria, whereas the breakdown rate in *Saccharomyces cerevisiae* is 50%. Sanz-Penella et al. (2012) examined the effect of phytase purified from *Bifidobacterium longum* spp. *infantis* and *Bifidobacterium pseudocatenulatum* on phytate in cereal products and found that both microorganisms were effective in reducing phytate content. As a result of the study, it was reported that the addition of exogenous phytases reduced the

phytate content by 68.6 to 93.4%. In another study investigating the phytase production capacity of lactic acid bacteria, microorganisms isolated from rye sourdough were examined and *Pediococcus pentosaceus* KTU05-8 and KTU05-9 strains were found to have the highest extracellular phytase activity. In addition, it was determined that the solubility of iron, zinc, manganese, calcium and phosphorus increased by 30% on average with *Pediococcus pentosaceus* strains used in the preparation of whole meal wheat bread (Cizeikiene et al., 2015). There is insufficient research in the literature on the use of probiotic microorganisms in the soaking process, one of the gastronomic applications. In this regard, it is considered important to examine the subject in terms of culinary applications.

Although many studies have investigated thermal processing, germination or controlled fermentation to reduce phytate, there is a lack of research on the use of naturally probiotic liquids such as kefir and pickle juice as soaking media for whole chickpeas. Existing studies mainly focus on flour fermentation or enzyme-assisted treatments. This study therefore addresses an important research gap by evaluating the effects of kefir, pickle juice and their mixtures on the phytic acid content and quality attributes of chickpeas.

## 2. Materials and Methods

This research was carried out to examine the effects of soaking with pickle juice and kefir, which are known to be rich in probiotic microorganisms, on chickpeas, especially phytic acid levels. In the experiment, chickpea samples were kept in five different liquids for two different periods of time (24 hours and 48 hours). The kefir and pickle juice used in this study were commercially available products marketed as probiotic beverages. Although the microbial loads of these specific products were not directly measured, kefir is typically reported to contain  $10^7$  CFU/mL lactic acid bacteria and  $10^6$  CFU/mL yeasts (Alves et al., 2021). These literature-based microbial levels were considered when interpreting the potential probiotic effect of the soaking liquids.

After soaking, the samples were coded as follows: water-only (SCW), pickle-only juice (SCPJ), pickle-juice/water mixture (SCPJ+W), kefir-only (SCK), and kefir/water mixture (SCK+W) (Figure 1). While the chickpeas used in the study were supplied by the domestic producer, the liquids (pickle juice and kefir) in which the chickpea samples were soaked were purchased from local markets. The effects of soaking were evaluated by determining the phytic acid content of the samples, together with moisture, ash, protein, fat and color parameters.

Figure 1 demonstrates a brief overview of soaking liquids and soaking duration.

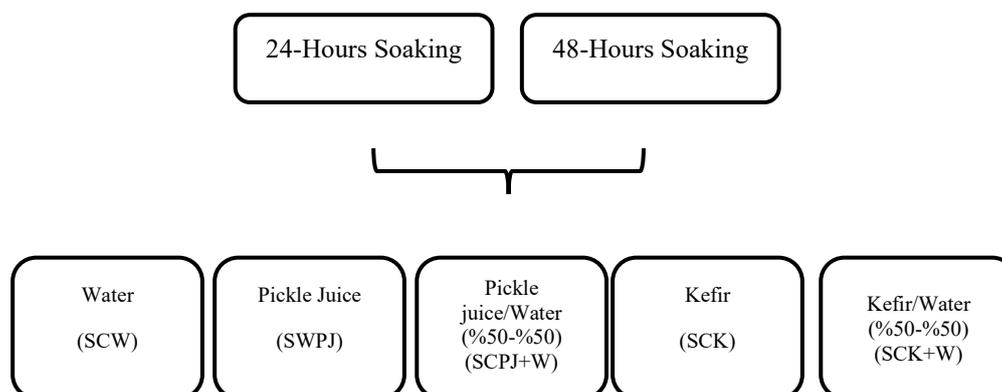


Figure 1. Soaking of chickpea samples

### 2.1 Laboratory Analyses

#### Phytic acid analysis

Phytic acid determination was carried out by colorimetric method developed by Haug and Lantzsch (1983). In this method, phytic acid extracted with hydrochloric acid from the samples was precipitated with iron (III) solution, then the amount of iron remaining in the serum was measured spectrophotometrically. The microbial composition and viable cell counts of the soaking liquids were not determined experimentally; therefore, interpretations regarding probiotic activity are based on typical microbial contents reported in the literature.

### Chemical analyses

The water content of the samples was determined by drying at 135 °C for 2.5 hours according to the AACC 44-19 standard. Ash amounts were measured by burning at 550 °C in a muffle oven with AACC 08-01 method, and protein amounts were measured by Kjeldahl method (AACC 46-12). The oil content was determined using the Soxhlet system in accordance with the AACC 30-25 protocol (AACC, 1990).

### Color analysis

Color analyses were performed with Minolta CR-400 device; lightness (L\*), redness/foilage (a\*) and yellowness/blueness (b\*) values were recorded. These parameters are among the important quality indicators in terms of appearance in foods (Francis, 1998).

### Statistical analyses

A package program (SPSS 29.0) was used for statistical analysis and the differences in samples were tested for statistical significance. Duncan's multiple range test was used to distinguish among the mean values. Standard deviations were computed using the same software. Analyses were performed in two replicates.

## 3. Results and Discussion

### 3.1. Phytic acid content and some chemical properties of chickpea samples

Table 1 presents the variances of analysis results concerning phytic acid contents of soaked chickpea samples. The results of Duncan's multiple are summarized in Table 2.

**Table 1. Variance analyses results of the phytic acid content of chickpea samples**

VS	DF	Phytic acid	
		MS	F
Soaking liquid	4	45636	162,9**
Soaking duration	2	557779	3983**
Error	15		1050

\*\* p< 0.01

**Table 2. Results of Duncan test for phytic acid content. SCW: soaked in water; SCPJ: soaked in pickle juice; SCPJ+W: pickle juice/water (1:1); SCK: soaked in kefir; SCK+W: kefir/water (1:1).**

Factor	n	Phytic acid (mg 100 g <sup>-1</sup> )
<b>Soaking liquid</b>		
SCW	6	619.46 <sup>a</sup>
SCPJ	6	581.43 <sup>b</sup>
SCPJ+W	6	612.89 <sup>a</sup>
SCK	6	514.08 <sup>d</sup>
SCK+W	6	553.79 <sup>c</sup>
<b>Soaking duration(hours)</b>		
0	10	757.98 <sup>a</sup>
24	10	541.54 <sup>b</sup>
48	10	429.46 <sup>c</sup>

Statistically significant ( $p < 0.01$ ) differences specific to the soaking liquid factor were observed in phytic acid contents of the chickpea samples for 24 hours and 48 hours soaked (Table 1). Among the chickpea samples, the lowest phytic acid content was detected only in the sample kept in kefir (514.08 mg 100 g<sup>-1</sup>). This result reveals that kefir provides an effective environment in breaking down phytic acid. Samples soaked with a kefir/water mixture followed; A moderate decrease was observed in the groups using pickle juice. This supports that probiotic sources may be effective in reducing phytic acid content. The stronger effect of kefir compared to pickle juice may be due to its microbial composition. Kefir contains a mixed microbial consortium of lactic acid bacteria, yeast species, and acetic acid bacteria, a significant portion of which possess the capacity to naturally produce phytase. Furthermore, the lower pH of kefir increases the solubility of phytic acid and creates an environment that supports phytase activity. In pickle juice, however, a more limited number of LAB predominate, and the salt content may relatively limit enzyme activity. These microbial and chemical differences explain why kefir degraded phytic acid more effectively in our study.

Table 3. Variance analyses results of chemical properties of chickpea samples<sup>1</sup>

VS	DF	Moisture		Ash		Protein		Fat	
		MS	F	MS	F	MS	F	MS	F
Soaking liquid	4	18.20	63.88**	0.13	17.05**	1.28	2.99ns	1.38	20.76**
Soaking duration	2	14071	98782**	1.70	462.2**	14.42	67.10**	0.09	2.55ns
Error	15		1.07		0.03		1.61		0.25

\*\*  $p < 0.01$ , ns: not significant

Table 4. Results of Duncan's multiple comparison test on the chemical properties of chickpea; SCW: soaked in water; SCPJ: soaked in pickle juice; SCPJ+W: pickle juice/water (1:1); SCK: soaked in kefir; SCK+W: kefir/water (1:1).

Factor	n	Moisture (%)	Ash (%)	Protein (%)	Fat (%)
<b>Soaking liquid</b>					
SCW	6	40.02 <sup>a</sup>	2.40 <sup>a</sup>	16.87 <sup>a</sup>	5.02 <sup>c</sup>
SCPJ	6	37.77 <sup>d</sup>	2.31 <sup>b</sup>	16.72 <sup>ab</sup>	5.55 <sup>a</sup>
SCPJ+W	6	38.99 <sup>b</sup>	2.35 <sup>ab</sup>	16.31 <sup>b</sup>	5.29 <sup>b</sup>
SCK	6	38.15 <sup>c</sup>	2.21 <sup>c</sup>	16.79 <sup>a</sup>	4.97 <sup>c</sup>
SCK+W	6	38.96 <sup>b</sup>	2.25 <sup>c</sup>	16.48 <sup>ab</sup>	5.11 <sup>c</sup>
<b>Soaking duration(hours)</b>					
0	10	8.16 <sup>c</sup>	2.61 <sup>a</sup>	17.56 <sup>a</sup>	5.12 <sup>b</sup>
24	10	53.40 <sup>b</sup>	2.27 <sup>b</sup>	16.45 <sup>b</sup>	5.18 <sup>ab</sup>
48	10	54.77 <sup>a</sup>	2.03 <sup>c</sup>	15.89 <sup>c</sup>	5.25 <sup>a</sup>

Statistically significant decreases in phytic acid levels were noted with prolonged soaking time ( $p < 0.01$ ) (Table 1). In particular, the 48-hour soaking process resulted in a reduction of approximately 43% in the average amount of phytic acid in the samples. This finding suggests that prolonging the duration contributes to phytic acid breakdown by increasing endogenous phytase enzyme activity. While the average phytic acid content of the samples that were not subjected to any soaking process was found to be 757.98 mg 100 g<sup>-1</sup>, it was observed at the end of 24 hours- and 48 hours-soaking that the figures were 541.54 mg 100 g<sup>-1</sup> and 429.46 mg 100 g<sup>-1</sup>, respectively. These results are consistent with studies reported in the literature. For example, Mehanni et al. (2021) reported a 7–15% reduction in phytic acid after a 12-hour soak with water alone. The approximately 43% reduction achieved in our study over a 48-hour period suggests that probiotic-containing liquids may have a stronger effect on phytic acid. A research on sourdough fermentation revealed that after 24 hours, phytic acid

level reduced by 42.9%-96.6%. The addition of phytase-producing bacteria demonstrates that fermentation may efficiently breakdown phytic acid, with fermentation duration being a significant factor influencing this degradation. The breakdown rate of phytic acid in single-strain fermented sourdough was inferior to that of the mixed fermentation group, likely attributable to the synergistic action of phytase generated by lactic acid bacteria and yeasts in degrading phytic acid (Fang et al., 2023).

In addition to the phytic acid content of chickpea samples, which were soaked in different liquids, the moisture, ash, protein and fat contents were observed (Tables 3 and 4). The different liquids used had an impact on the chemical composition of chickpeas. In particular, significant changes are observed in moisture, ash and oil content; There was no significant difference in protein content. Lower moisture and ash content were measured in samples kept in kefir. The amount of oil has increased, especially in the pickle juice group. As the soaking time was prolonged, an increase in moisture content was observed, while significant decreases occurred in the amount of ash and protein. This can be explained by the increase in soluble mineral and protein fractions that pass into the water.

### 3.2. Color properties of chickpea samples

While the variance analysis results of the color values of the chickpea samples are presented in Table 5, Duncan's multiple range test results are summarized in Table 6.

**Table 5. Variance analyses results of color values of chickpea samples<sup>1</sup>**

VS	DF	L*		a*		b*	
		MS	F	MS	F	MS	F
Soaking liquid	4	4.89	2.80ns	0.33	24.55**	42.26	20.89ns
Soaking duration	2	31.76	36.34**	2.39	355.78**	79.99	79.10**
Error	15	6.56		0.05		7.59	

\*\* p< 0.01, ns: not significant

Color values that affect the visual quality of food products are also affected by the soaking process. The highest value in terms of L\* (lightness) values was measured only in samples kept in water. The longer the soaking time, the brighter appearance was formed in the samples. a\* (green-red) values decreased especially at the end of 48 hours, while b\* (blue-yellow) values generally tended to decrease. These changes may be associated with the transition of color pigments to the wetting liquid.

**Table 6. Results of Duncan's multiple comparison test on the color values of chickpea samples; SCW: soaked in water; SCPJ: soaked in pickle juice; SCPJ+W: pickle juice/water (1:1); SCK: soaked in kefir; SCK+W: kefir/water (1:1).**

Factor	n	L*	a*	b*
<b>Soaking liquid</b>				
SCW	6	88.62 <sup>a</sup>	0.21 <sup>a</sup>	21.06 <sup>b</sup>
SCPJ	6	87.66 <sup>b</sup>	-0.07 <sup>d</sup>	23.83 <sup>a</sup>
SCPJ+W	6	87.81 <sup>b</sup>	-0.04 <sup>d</sup>	24.24 <sup>a</sup>
SCK	6	87.52 <sup>b</sup>	0.04 <sup>c</sup>	24.03 <sup>a</sup>
SCK+W	6	87.57 <sup>b</sup>	0.14 <sup>b</sup>	23.90 <sup>a</sup>
<b>Soaking duration (hours)</b>				
0	10	86.54 <sup>c</sup>	0.24 <sup>a</sup>	25.63 <sup>a</sup>
24	10	87.91 <sup>b</sup>	0.27 <sup>a</sup>	22.87 <sup>b</sup>
48	10	89.06 <sup>a</sup>	-0.34 <sup>b</sup>	21.74 <sup>c</sup>

#### 4. Conclusions

This research aimed to investigate the impact of soaking in liquids on the reduction of naturally occurring phytic acid in grains and legumes. In the study, chickpea samples were soaked in different liquids for 24 hours and 48 hours, and a range of physical and chemical properties of the chickpea samples, particularly the phytic acid they contain, were analyzed. The reason behind choosing kefir and pickle juice as soaking liquid was their potential to contain probiotic microorganisms. It is asserted that probiotic microorganisms play a role in reducing phytic acid, and the main aim is to observe this effect on chickpeas. These results show that soaking chickpeas in kefir for 24–48 hours can significantly reduce phytic acid content, even in home-style meal preparation. The soaking liquids yielding remarkable results in terms of reducing the phytic acid content were found to be kefir and a kefir/water mixture, followed by pickle juice, and these are among the most prominent findings concluded in the study. The study revealed that the soaking process significantly reduced the phytic acid content of the chickpea samples and the phytic acid levels decreased further with the soaking duration being extended. It was reported that soaking results in further reduced phytic acid. In their study, the authors revealed that while the phytic acid content of the control chickpea sample was determined as 719.26 mg 100 g<sup>-1</sup>, the value decreased to 668.66 mg 100 g<sup>-1</sup> after soaking in water for 12 hours (Mehanni et al., 2021). Ibrahim et al. (2002) reported that 8-12 hours of soaking caused a minor change in the amount of phytic acid, while 16 hours of soaking led to a statistically significant reduction. This state of affairs was associated with the activation of endogenous phytase during a long soaking process.

Moreover, it was revealed that soaking liquid factor has a significant effect on moisture, ash and fat content of the chickpea samples while the protein content was not significantly affected by the variety of soaking liquid. Soaking duration resulted in statistically significant decreases in the ash and protein content of the samples. Shafaei et al. (2016) reported that an increase occurred in the moisture content of the chickpeas based on the duration of soaking. Another study revealed that extended duration of soaking resulted in a decrease in ash and protein contained by the chickpea samples (Maqbool et al., 2017). The reduction in ash and protein content is considered to be associated with the transfusion of mineral substances and soluble proteins into the soaking liquid.

The average L\*, a\* and b\* values of the chickpea samples, which were not subjected to the soaking process, were found to be 86.54, 0.24 and 25.63, respectively. In their measurements on chickpea flour, Maqbool et al. (2017) found L\*, a\* and b\* values as 87.66, -0.86 and 30.93, respectively, while Barişik and Tavman (2018) noted that L\*, a\* and b\* values were 83.46, 0.60 and 23.88, respectively. While the soaking factor did not cause a significant change in the L\* and b\* values of the samples, statistically significant changes were observed in all color parameters depending on the soaking duration. It is considered that the decrease in a\* and b\* values is associated with the increase in the number of color pigments transfused into the water during the soaking process. In his study on legume bulgur production, Ertaş (2010) found that the chickpea samples that he used as raw material had L\* value of 51.56, and that the average value was 66.77 after 12 hours of soaking. Furthermore, it was reported that the brightness continued to increase as the duration of soaking was extended and it was emphasized that the increase concern resulted from the dilution of the color in relation to the water uptake during the soaking process.

This study evaluated only one chickpea variety, and the microbial load of the kefir and pickle juice used was not directly measured. Therefore, assessments of probiotic efficacy are based on typical microbial levels reported in the literature. Furthermore, mineral bioavailability was not directly measured. These issues can be considered limitations of the study.

With the increase in consumer awareness, it has become essential to explore alternate techniques for food processing and preservation to satisfy the demand for natural goods (Şensoy and Tarakçı, 2023). In light of the findings obtained, it was highlighted that soaking the legumes in water before cooking is important and it was revealed that kefir as an important probiotic source will yield more effective results in reducing the phytic acid when used as a soaking liquid. This study added a probiotic dimension to the soaking method, which is frequently used in kitchen applications, and revealed the phytic acid reduction potential of fermented liquids such as kefir. Prolongation of soaking time and use of probiotic liquids have been considered as an effective method to increase nutritional usefulness. This approach can pave the way for innovative practices in both traditional and scientific gastronomy fields.

Future studies could investigate the effects of different chickpea varieties, other legumes, soaking liquids

enriched with controlled probiotic cultures, and different temperature-time combinations. Furthermore, the effect of phytic acid reduction on mineral bioavailability should be directly investigated using in vitro digestion models or mineral dialysis/simulation methods.

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#### **Ethical Statement**

There is no need to obtain permission from the ethics committee for this study.

#### **Conflicts of Interest**

We declare that there is no conflict of interest between us as the article authors.

#### **Authorship Contribution Statement**

Concept: Madenci, A. B., Okur, B.; Design: Madenci, A. B.; Data Collection or Processing: Madenci, A. B., Okur, B.; Statistical Analyses: Madenci, A. B., Okur, B.; Literature Search: Madenci, A. B., Okur, B.; Writing, Review and Editing: Madenci, A. B., Okur, B.

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