Physical and Sensory Characteristics of Synbiotic Yogurt with the Addition of Pomegranate Peel (*Punica granatum* L.) Extract

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Abstract. Pomegranate peels are agricultural waste that still contains bioactive compounds, such as polyphenols and polysaccharides, which act as natural antioxidants and prebiotics. Polysaccharides exert prebiotic effects by promoting the growth and activity of beneficial lactic acid bacteria. In this study, we aimed to develop a new yogurt product by utilizing pomegranate peel (*Punica granatum* L.) extract. The yogurt was made using skim milk powder and the lactic acid bacteria strains *Lactobacillus bulgaricus* and *Streptococcus thermophilus* as the main ingredients. The synbiotic yogurt was made using different concentrations of pomegranate peel extract at T0 (control), T1 (0.5%), T2 (1%), and T3 (1.5%). Physical characteristic tests include the pH, syneresis, and water holding capacity. Sensory analysis was conducted on 30 panelists using a 5-point Likert scale with test parameters including aroma, taste, color, and overall acceptability. The results revealed significant differences ($p<0.05$) in the pH, syneresis, and sensory aroma values of synbiotic yogurt. The addition of pomegranate peel extract to yogurt resulted in an average pH between 4.07 – 4.30, syneresis between 34.80 – 44.38% and aroma value of 3.77 – 4.12. In terms of sensory quality, yogurt with the addition of pomegranate peel extract was almost identical to the control, except for T2 due to its strong sour aroma. In conclusion, synbiotic yogurt with 0.5% pomegranate peel extract was the best of all the treatments. Thus, the pomegranate peel extract formulated into yoghurt can be considered as a functional ingredient to improve yogurt's physical and sensory characteristics.

Keywords: Pomegranate peel extract, Sensory characteristics, Synbiotic yogurt, Syneresis, Water holding capacity

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1 Introduction

Pomegranate peels are agricultural waste that still contains phytochemical components of bioactive compounds that can be used to enhance human health benefits. The estimated area of pomegranate cultivation in the world exceeds 300,000, hectares with a production yield of around 3 million tons per year. The percentage of pomegranate peel reaches about 50 – 60% of the total weight of the fruit [1], resulting in an estimated waste production from pomegranate cultivation worldwide of around 1.62 tons/year. A small amount of pomegranate peel is utilized as animal feed, natural dye, and traditional medicine. However, the majority is still not optimally utilized, posing a risk of environmental pollution if not properly managed. The high levels of bioactive compounds such as polyphenols, phenolic compounds, flavonoids, tannins, anthocyanins, and organic acids in pomegranate peels have significant health benefits [2]. Various *in vitro* and *in vivo* tests have been conducted to identify the health benefits derived from pomegranate peel, one of which is to support digestive health.

The polysaccharides contained in the pomegranate peel are known to have prebiotic activities that can enhance the growth of probiotics, thus playing a role in maintaining the balance of gut microbiota and digestive health. The main polysaccharide found in pomegranate peel is pectin, which constitutes 20 – 25% [1]. Pectin is classified as a dietary fiber source that is beneficial for the digestive system, helping to reduce gastrointestinal transit time, reduce glucose absorption, and increase fecal mass [3].

Yogurt is highly susceptible to physical and sensory deterioration. The quality of yogurt depends not only on the composition of raw materials, the fermentation process, and the type of starter culture, but also on the inclusion of functional additives. The use of different functional additives represents an effort to meet diverse consumer preferences while enhancing the functionality of yogurt products. In this study, we aimed to develop a new yogurt product by utilizing pomegranate peel. The application of pomegranate peel in dairy processing products has a significant effect on improving sensory properties, total acceptance, viability of lactic acid bacteria, and shelf life of yogurt [4]. The addition of pomegranate peel extract can serve as a functional ingredient to enhance the physical and sensory characteristics of yogurt. This effect can be attributed to the presence of bioactive compounds, such as polyphenols and polysaccharides, which act as natural antioxidants and prebiotics. Polyphenols may interact with milk proteins, improving gel structure, water-holding capacity, and reducing syneresis, while polysaccharides exert prebiotic effects by promoting the growth and activity of beneficial lactic acid bacteria. The combination of prebiotics from pomegranate peel with probiotics *Lactobacillus bulgaricus* and *Streptococcus thermophilus* is expected to produce synbiotic yogurt that has better physical and sensory qualities compared to conventional yogurt.

2 Materials and Methods

2.1 Materials

The materials used for this research were skim milk powder (Prolac) and pomegranate peel extract powder obtained from the local market. With a low temperature extraction and drying process, pomegranate peel extracts dissolve completely without residue, contain more active substances (Herbilogy). Additionally, dried yogurt starter cultures *Lactobacillus bulgaricus* and *Streptococcus thermophilus* (Yogourmet®) were imported from Canada, and aquadest was used. The equipment used were digital scales (Mettler Toledo ME204), pH meter (Ohaus), autoclave (SES, 2000), and centrifuge (Eppendorf).

2.2 Methods

The research methodology was a laboratory experiment using a Completely Randomized Design (CRD) with four different treatments containing pomegranate peel extract (control, 0.5%, 1%, and 1.5%) (w/v), which repeated four replications, respectively.

2.2.1 Formulation of Synbiotic Yogurt

Synbiotic yogurt was made using [5] reference with few modifications. 10 grams of skim milk powder was dissolved in 100 ml of aquadest, then pasteurized at a temperature of 65°C for 15 minutes. The temperature was lowered to 45°C, then pomegranate peel extract was added according to the treatment (0%, 0.5%, 1%, and 1.5%). After homogenization, inoculation was performed by adding 3% (w/w) of the starter culture *Lactobacillus bulgaricus* and *Streptococcus thermophilus* and stirring. The inoculated milk samples were then incubated at room temperature for 24 hours. After fermentation was completed, the yogurt was stirred and stored in 4°C.

2.2.2 Potential of Hydrogen (pH)

The pH of yogurt was measured using [5] procedure. 5 grams of yogurt sample were placed in a beaker glass, then measured using a pH meter (Ohaus) for approximately 1 minute until the measurement result stabilized.

2.2.3 Syneresis

The release of water in the gel indicates the ability of whey protein networks to bind water. The separation of whey is measured based on the procedure by [5] with slight modifications. A 15 ml sample of yogurt is placed in a 50 ml centrifuge tube and then centrifuged at a speed of 2000 rpm for 15 minutes. The results of the centrifugation, comprising liquid and sediment, are weighed using a digital scale using the formula:

$$Syneresis\ (\%) = \frac{Initial\ sample\ weight\ (g) - Liquid\ weight\ (g)}{Initial\ sample\ weight\ (g)}\ x\ 100\% \quad (1)$$

2.2.4 Water Holding Capacity

The Water Holding Capacity is measured based on the research [5]. 15 ml of sample is placed in a 50 ml centrifuge tube and then centrifuged at a speed of 5000 rpm and a temperature of 20°C for 10 minutes. The liquid is separated from the yogurt sediment and then weighed. The percentage of water holding Capacity is calculated using the formula:

$$Water\ Holding\ Capacity\ (\%) = \frac{Initial\ sample\ weight\ (g) - Precipitate\ weight\ (g)}{Initial\ sample\ weight\ (g)}\ x\ 100\% \quad (2)$$

2.2.5 Sensory Analysis

Sensory analysis was conducted based on the research by [6]. A 5-point Likert scale (1 = extremely dislike and 5 = extremely like) was used to evaluate the sensory values of the synbiotic yogurt (Table 1). The synbiotic yogurt samples were analyzed by 30 untrained panelists aged 20 – 28 years. The sensory analysis included four parameters: aroma, taste, color, and overall total acceptance. The samples were tested individually with the panelists

under controlled environmental conditions (temperature 27°C and relative humidity 60%). To minimize bias or carryover effects, the sensory analysis was conducted in a clean room (odor-free), with adequate rest intervals between evaluations, and drinking water was provided to neutralize the palate after each sample.

Table 1. Sensory Analysis Scale for Synbiotic Yogurt with the Addition of Pomegranate Peel Extract.

Indicator	Scale	Description
Aroma	1	Very sour, deviant (abnormal) aroma
	2	Strong sour aroma, deviant aroma present
	3	Characteristic yogurt aroma, deviant aroma present
	4	Characteristic yogurt aroma, no deviant aroma
	5	Characteristic yogurt aroma (fresh sour)
Taste	1	Very sour (dominant sour taste, bitter, unpleasant)
	2	Sour and foreign taste
	3	Enough (normal)
	4	Delicious (sour-sweet)
	5	Very delicious (sour-sweet-fresh)
Color	1	Pale, uninteresting
	2	Pale, less interesting
	3	Milky white (normal)
	4	Milky white, interesting
	5	Milky white, very interesting
Overall Acceptability	1	Very disliked
	2	Disliked
	3	Neutral
	4	Liked
	5	Very much liked

2.3 Statistical Analysis

The data were presented as means with standard deviations. A one-way analysis of variance (ANOVA) was performed to analyze the data, followed by Duncan's multiple range test at a 95% confidence level ($P<0.05$) using SPSS software version 22.0.

3 Results and Discussion

3.1 Physical Characteristics

Table 2 below shows the results of the addition of different pomegranate peel extracts T0 (control), T1 (0.5%), T2 (1%), and T3 (1.5%) on the physical quality of yogurt, including pH, syneresis, and water holding capacity.

Table 2. Physical characteristics of synbiotic yoghurt with the addition of pomegranate peel extract.

Treatment	pH	Syneresis (%)	Water Holding Capacity (%)
T0	4.07^{a}±0.019	34.80^{a}±0.015	74.89±0.941
T1	4.21^{b}±0.861	38.86^{ab}±0.277	77.40±0.485
T2	4.30^{c}±0.331	44.38^{b}±0.251	74.27±0.465
T3	4.26^{bc}±0.018	40.25^{ab}±0.715	73.69±0.198

The values are Mean±Standard deviation. $^{a-c}$ means with different superscript in each coloumn are significantly different ($p<0.05$)

T0: Control (without pomegranate peel extract), T1: 0.5% pomegranate peel extract, T2: 1% pomegranate peel extract, and T3: 1.5% pomegranate peel extract.

3.1.1 Potential of Hydrogen (pH)

The research results showed a significant difference ($p<0.01$) in pH with the addition of pomegranate peel extract at different concentrations in yogurt production. The average pH value in this study was 4.07-4.30. Food and Drug Administration sets the acidity standard for yogurt products is ≤ 4.6. Meanwhile, based on the Indonesian National Standards (SNI), the quality requirement for good yogurt has a pH value ranging from 3.80-4.50. In this study, the pH values were within the acidity limits allowed by both standards. This indicates that the addition of pomegranate peel extract at various concentrations did not decrease the acidity of yogurt beyond the safe limit, although there was a significant increase in pH.

The increase in pH, along with the rising concentration of pomegranate peel extract, is suspected to be due to the alkaline nature of the bioactive compounds in pomegranate peel extract, which can act as a buffer. Pomegranate peel extracted using ultrasonic probe sonication yields pH values between 7 and 8 [7]. The alkaline nature of pomegranate peel extract is produced by anthocyanin compounds with anionic quinoidal base structures. Furthermore, the significance of the pH increase in yogurt with the addition of varying concentrations of pomegranate peel extract occurs due to differences in the culture strains used. The characteristics of lactic acid bacteria exhibit varying levels of tolerance for their growth. S. thermophilus can thrive and survive at pH 5, while *L. delbrueckii* subsp. *bulgaricus* and *L. casei* thrive at pH 4 [8].

3.1.2 Syneresis

Syneresis is the release of water from the gel caused by a decrease in the ability of the whey protein to bind water. The shrinkage of the protein network's three-dimensional structure causes syneresis, resulting in weakened whey protein binding strength and their separation from the yogurt. The syneresis value in the yogurt sample showed significant results ($p<0.05$). In this study, the percentage of syneresis increased with the addition of pomegranate peel extract. High concentration of pomegranate peel extract would increase syneresis in yogurt due to changes in the protein gel matrix [9]. The presence of pectin polysaccharides in the pomegranate peel extract plays a role in strengthening the protein gel's work and water-holding capacity, thus reducing syneresis in yogurt. However, the addition of pomegranate peel extract at suboptimal concentrations is suspected to cause saturation, which increases the hydrophilic properties of the gel matrix and disrupts the stability of the gel structure, triggering an increase in liquid release (syneresis). Similarly, [10] indicated that the supplementation of 1% green and black tea extracts increased syneresis in yogurt samples.

The destabilization of the syneresis value occurs in yogurt samples with the addition of 1% pomegranate peel extract. The addition of 0.5% and 1.5% pomegranate peel extract is

almost identical to the control. When the concentration of pomegranate peel extract is added at 1.5%, the syneresis value of the yogurt decreases due to the role of polysaccharides (pectin) as an emulsifying agent [11]. The ingredients and the number of materials used in the production of yogurt are important to pay attention to as they play a role in the rearrangement of the protein gel matrix.

3.1.3 Water Holding Capacity

Water holding capacity is the ability of milk proteins to bind water. Research results show no effect ($p>0.05$) of the addition of pomegranate peel extract with different concentrations on the water binding capacity of yogurt. Pomegranate peel powder added with chitosan in the process of making edible films can increase film thickness due to its high permeability [12]. The High permeability of protein gel will facilitate water exit from the gel matrix, resulting in low water binding capacity. The bioactive component pectin from pomegranate peel extract contains free hydroxyl groups. Milk proteins are composed of hydroxyl (-OH) and amino (-NH2) groups. The interaction between the hydroxyl groups of pectin and the hydroxyl groups of milk proteins will form hydrogen bonds, which causes a decrease in the number of active groups that can interact with free water molecules. This causes the ability of the water binding capacity in the gel matrix to decrease.

Although the water-holding capacity of the yogurt samples did not show significant differences, there was a tendency for the percentage of water-holding capacity to decrease with increasing concentrations of pomegranate peel extract. This decrease is suspected to be influenced by the presence of bioactive components in the pomegranate peel extract, such as polyphenols, tannins, and organic acids, which may interfere with the formation of bonds between casein proteins during the fermentation process [4]. Consequently, the gel structure formed becomes more fragile and permeable, reducing the gel matrix's ability to retain water.

3.2 Sensory Characteristics

Figure 1 shows the results of the panelists' assessment of the sensory characteristics of yogurt, which include aroma, taste, color, and overall acceptance. This assessment is used to determine the effect of the treatment on the quality of the produced yogurt.

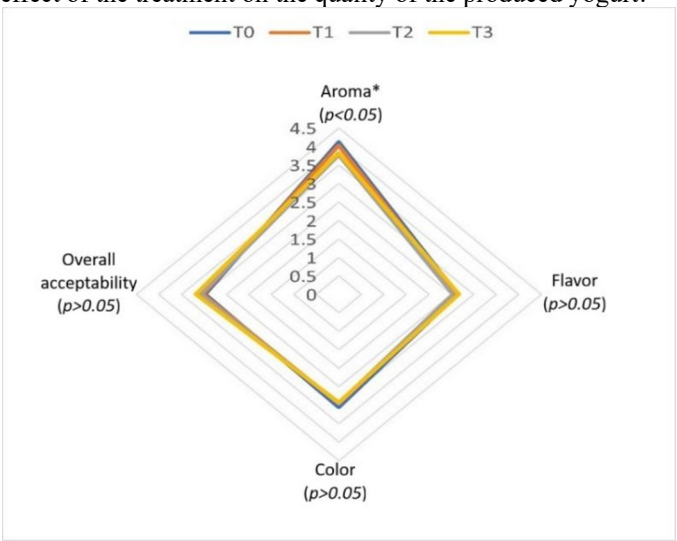

Fig. 1. Effects on The Sensory Attributes of Synbiotic Yogurt.

3.2.1 Aroma

The results of the panelists' assessments show that there is a significant effect of the use of pomegranate peel extract in yogurt on aroma. The aroma scores for each treatment, T0, T1, T2, and T3, were 4.12, 4.03, 3.77, and 3.83, respectively. These findings are consistent with the research by [2], which states that the use of pomegranate peel in yogurt can influence the aroma profile. The concentration of pomegranate peel extract determines the extent of the off-aroma that will arise in yogurt. In this study, Treatment T0 exhibited the highest score with the characteristic yogurt aroma category, showing no off-aroma. T0 was significantly different from T2, which had the lowest score, indicating the presence of an off-aroma in the yogurt. Treatments T1 and T3 showed no significant differences compared to T0 and T2. These results indicate that using 1% pomegranate peel extract can diminish the aroma quality of yogurt.

The influence of pomegranate peel extract on aroma can be attributed to volatile and phenolic compounds, such as tannins and flavonoids [2]. Both of these compounds can significantly affect the aroma of yogurt by the way phenolic compounds interact with proteins and lipids in the yogurt matrix, causing changes in the volatile profile. This interaction leads to inhibition in the release of aromatic compounds, potentially reducing the intensity of the characteristic yogurt aroma. Additionally, phenolic compounds can influence the fermentation process, resulting in the suppression or enhancement of certain aromas [13].

3.2.2 Flavor

The results of the sensory evaluation showed that there were no significant differences in taste among the yogurt fortified with pomegranate peel extract. The average taste scores for treatments T0 to T3 were 2.64, 2.59, 2.53, and 2.67, respectively. The panelists assessed that all yogurt samples had a normal taste. The lack of significant taste differences among the treatments is suspected to be due to the concentration of pomegranate peel extract used. In this study, the concentration of pomegranate peel extract used ranged from 0.5-1.5%. This amount likely was not sufficient to significantly influence the overall taste profile of the yogurt. The findings of this study are consistent with the research by [5], which reported that yogurt fortified with pomegranate peel extract up to 0.75% still had the same taste characteristics as the control yogurt, which had the typical taste of normal yogurt.

The addition of pomegranate peel extract is known to have an impact on flavor when used at concentrations of 5-30%. Based on the research of [6], the addition of 10%, 20%, and 30% pomegranate peel extract resulted in noticeable differences in yogurt flavor. At a concentration of 10%, pomegranate peel extract produced a fruit flavor with a hint of pomegranate, while concentrations of 20% and 30% led to a stronger pomegranate flavor accompanied by slight acidity. Similarly, the addition of 5–20% pomegranate peel extract caused significant flavor changes compared to yogurt without pomegranate peel extract. However, it was noted that the use of pomegranate peel extracts up to 35% did not provide a significant difference in flavor compared to the control.

In addition to the concentration of pomegranate peel extract added to the yogurt, the flavor profile can also be influenced by the extraction method. The type of solvent used during the extraction process, such as ethanol, methanol, and acetone, can yield different bioactive compounds, thereby affecting the taste of the yogurt [5]. Flavor variations are also influenced by differences in pomegranate fruit varieties. Furthermore, pomegranate peel extract storage conditions contribute to flavor influences. Temperature, light, and oxygen exposure can reduce the stability of certain bioactive compounds, thus causing changes in flavor [14].

3.2.3 Color

The main attraction that influences the sensory perception of food products is color. In this study, the results of statistical analysis on the panelists' evaluations of the color of yogurt with added pomegranate peel extract showed that there were no significant differences between treatments. The average color score for treatments T0 to T3 were 3.06, 2.96, 2.95, and 2.92, respectively. Panelists assessed all yogurt samples as having a normal pure white color typical of yogurt. These findings are consistent with the findings of [6], which reported no significant differences in the appearance of yogurt fortified with pomegranate peel extract compared to control yogurt without pomegranate peel extract. However, they differ from the findings of [9], who reported that the addition of 0.5% and 1% pomegranate peel extract resulted in noticeable color changes in yogurt.

Several factors can cause a lack of color difference. One possibility is the white base color of milk, which can mask the color changes produced by pomegranate peel extract. Additionally, [2] reported that anthocyanins in the pomegranate peel extract extract are sensitive to heat and pH, so during the yogurt-making process, there can be color degradation or loss of pigment intensity. Anthocyanins can also interact with yogurt proteins, which in turn can affect color stability and expression. Another influencing factor is the concentration of pomegranate peel extract used. In this study, the concentration of pomegranate peel extract is still relatively low, so it does not show a significant difference. This is supported by research from [6], which states that the use of pomegranate peel extract at concentrations of 10-30 mg per mL of milk can affect color intensity. In addition to concentration, the color change in yogurt fortified with pomegranate peel extract is also influenced by the extraction method used. Yogurt added with pomegranate peel extract in the form of powder showed different color characteristics compared to yogurt using pomegranate peel extract in microencapsulation form [9].

3.2.4 Overall Acceptability

The results of the panelists' assessment of the total acceptance of yogurt supplemented with pomegranate peel extract indicate that there are no significant differences among treatments. The average total acceptance values from T0 to T3 are 2.97, 3.02, 3.07, and 3.18, respectively. The panelists gave a neutral assessment of all yogurt samples. This indicates that the addition of pomegranate peel extract is as acceptable as yogurt without pomegranate peel extract. The absence of differences in total acceptance is likely due to the similarity in taste and color characteristics of the yogurt among treatments, which statistically also did not show significant differences. The findings of this study are in line with those reported by [5], which stated that yogurt fortified with 0.25 – 0.75% pomegranate peel extract showed taste, color, texture, and overall acceptance identical to the control yogurt.

Previous research by [6], reported that the addition of pomegranate extract to yogurt can enhance sensory properties, resulting in a significant difference in overall acceptance, color, aroma, flavor, and texture. However, in this study, only aroma showed differences, whereas color and taste did not differ significantly between treatments. The panelists' preference regarding taste may also influence the overall acceptance results. The overall acceptance of yogurt with added pomegranate extract is related to preferences for color and flavor, as well as the ability of bioactive compounds to modify sensory perception.

4 Conclusion

Pomegranate peel extract can be considered as a functional ingredient to improve yogurt's physical and sensory characteristics. Synbiotic yogurt with 0.5% pomegranate peel extract was the best of all the treatments with 4.21 of pH value, 38.86% of syneresis, 77.40% of water holding capacity, and improved its sensory characteristics. These findings suggest that pomegranate peel extract could be practically applied in the development of value-added dairy products, particularly functional yogurts. Future research should explore large-scale production feasibility, long-term storage stability, and *in vivo* validation of potential health benefits to strengthen the application of pomegranate peel extract in functional food development.

References

1. Arun, K. B., Madhavan, A., Anoopkumar, A. N., Surendhar, A., Liz Kuriakose, L., Tiwari, A., Sirohi, R., Kuddus, M., Rebello, S., Kumar Awasthi,M., Varjani, S., Reshmy, R., Mathachan Aneesh, E., Binod, P., & Sindhu, R. (2022). Integrated biorefinery development for pomegranate peel: Prospects for the production of fuel, chemicals and bioactive molecules. Bioresource Technology, 362, 127833. doi: 10.1016/j.biortech.2022.127833
2. Siddiqui, S. A., Singh, S., & Nayik, G. A. (2024). Bioactive compounds from pomegranate peels - Biological properties, structure–function relationships, health benefits and food applications – A comprehensive review. Journal of Functional Foods, 116, 106132. doi: 10.1016/j.jff.2024.106132
3. Lara-Espinoza, C., Carvajal-Millán, E., Balandrán-Quintana, R., López-Franco, Y., & Rascón-Chu, A. (2018). Pectin and pectin-based composite materials: Beyond food texture. Molecules, 23(4). doi: 10.3390/molecules23040942
4. Ibrahim, A., Awad, S., & El-Sayed, M. (2020). Impact of pomegranate peel as prebiotic in bio-yoghurt. British Food Journal, 122(9), 2911–2926. doi: 10.1108/BFJ-04-2019-0296.
5. Jany, J. F., Nupur, A. H., Akash, S. I., Karmoker, P., Mazumder, M. A. R., & Alim, M. A. (2024). Fortification of functional yogurt by the phytochemicals extracted from pomegranate peel. Applied Food Research, 4(2), 100479. doi: 10.1016/J.AFRES.2024.100479.
6. Bakhti, S., Bekada, A., Bouzouina, M., & Benabdelmoumene, D. (2025). Pomegranate Peel Extract Fortified Yogurt: Effect on Physicochemical, Microbiological and Sensory Quality of Functional Dairy Product. Asian Journal of Dairy and Food Research, 44(1), 8–15. doi: 10.18805/AJDFR.DRF-426.
7. Pore, S., Thorat, Y., Gaikwad, N., & Hosmani, A. (2024). Pomegranate peel extract as an eco-friendly acid–base indicator and pH indicator paper. Journal of the Iranian Chemical Society, 21(4), 1151–1162. doi: 10.1007/s13738-024-02989-w.
8. Deshwal, G. K., Tiwari, S., Kumar, A., Raman, R. K., & Kadyan, S. (2021). Review on factors affecting and control of post-acidification in yoghurt and related products. Trends in Food Science and Technology, 109, 499–512. doi: 10.1016/j.tifs.2021.01.057.
9. Temiz, H., & Ersöz, E. B. (2023). Determination of Some Quality Characteristics and Rheological Properties of Yoghurts Made Using Cow Milk and Soy Drink Mixture Enriched with Pomegranate Peel Extract. Journal of Agricultural Sciences, 29(2), 561–572. doi: 10.15832/ankutbd.1015063.
10. Celik, O. F., Kilicaslan, M., Akcaoglu, S., & Ozturk, Y. (2023). Improving the antioxidant activity of yogurt through black and green tea supplementation.

International Journal of Food Science and Technology, 58(11), 6121–6130. doi: 10.1111/ijfs.16722.

11. Hu Zhuang, Shang Chu, Ping Wang, Bin Zhou, Lingyu Han , Xiongwei Yu, Qinli Fu, and S. L. (2019). Study on the Emulsifying Properties of Pomegranate Peel Pectin from Di erent Cultivation Areas. Molecules, 24(1819), 1–14. doi: http://dx.doi.org/10.3390/molecules24091819.
12. Zeng, J., Ren, X., Zhu, S., & Gao, Y. (2021). Fabrication and characterization of an economical active packaging film based on chitosan incorporated with pomegranate peel. International Journal of Biological Macromolecules, 192(July), 1160–1168. doi: 10.1016/j.ijbiomac.2021.10.064.
13. Man, G., Xu, L., Wang, Y., Liao, X., & Xu, Z. (2022). Profiling Phenolic Composition in Pomegranate Peel From Nine Selected Cultivars Using UHPLC-QTOF-MS and UPLC-QQQ-MS. Frontiers in Nutrition, 8, 807447. doi: 10.3389/FNUT.2021.807447/BIBTEX.
14. Magangana, T. P., Makunga, N. P., Fawole, O. A., & Opara, U. L. (2020). Processing Factors Affecting the Phytochemical and Nutritional Properties of Pomegranate (*Punica granatum L.*) Peel Waste: A Review. Molecules 2020, Vol. 25, Page 4690, 25(20), 4690. doi: 10.3390/molecules25204690.