Original scientific paper

UDK: 637.35

Quality and shelf-life improvement of Kashar cheese using basil seed gum-based coatings and films

DOI: 10.15567/mljekarstvo.2025.0402

Aysun Oraç[1,2], Çiğdem Konak Göktepe[1,2], Talha Demirci[1], Nihat Akın[1]*

[1]Selçuk University, Faculty of Agriculture, Department of Food Engineering, Konya 42130, Türkiye
[2]Selçuk University, Karapınar Aydoğanlar Vocational School, Department of Food Processing, Konya 42400, Türkiye

Received: 13.01.2025. **Accepted:** 15.09.2025.

*Corresponding author: aysunorac@selcuk.edu.tr

Abstract

Cheese packaging systems play a crucial role in preventing undesirable reactions and defects during the ripening process. In recent years, consumer demand for healthy and natural products has increased dramatically. In this regard, biodegradable and edible packaging materials have gained considerable interest. Recent studies have pointed to green alternatives, mainly natural polymers, for conventional plastic-based packaging of cheeses. This research investigated the efficacy of basil seed gum as an edible film and coating material in preserving the physicochemical, microbiological, textural and antioxidant properties of Kashar cheese during 60 days of storage. Nine coating solutions were prepared with different concentrations of gum (0.5 %, 1.0 %, 1.5 %) and plasticizer (1 %, 3 %, 5 %). Basil seed gum-based coatings reduced weight loss, inhibited *Escherichia coli* and *Salmonella* Typhimurium, and increased antioxidant activity with increasing gum concentration. Textural and microbiological properties were also improved, improving the shelf life and quality of the cheese.

Keywords: Kashar cheese; basil seed gum; coating; edible film; ripening

Introduction

Kashar is a semi-hard cheese, ranking as the second most produced and consumed cheese in Türkiye, after Beyaz cheese (Seydim et al., 2020). It is produced by scalding and kneading acidified curd and is consumed either fresh or ripened. The ripening process typically lasts 3-6 months under controlled conditions of 8-12 °C and 70-75 % relative humidity, which contribute to the development of its characteristic flavor and texture. However, if the air quality and environmental conditions in the ripening rooms, particularly temperature and humidity, are not properly controlled, pathogenic and spoilage microorganisms may contaminate and proliferate on the cheese surface (Ozturkoglu-Budak et al., 2021). This can lead to significant economic losses, as the growth of toxic molds on the cheese crust can cause an average product loss of 8 %, as well as posing a public health risk (Ozdemir and Demirci, 2006).

The packaging systems implemented during the ripening period or storage are important in terms of preventing many negative reactions and cheese defects. The vacuum packaging method is mostly applied in Kashar cheese, and synthetic materials such as polyethylene, polypropylene, polyvinyl chloride, and polysterol are used. However, vacuum packaging application alone cannot provide full protection in concerned of microbial aspects. Innovative applications, such as antimicrobial films and coatings, active packaging, and edible biopolymer-based packaging have become the focus of attention to provide better protection during storage (Al-Tayyar et al., 2020).

Basil seed gum (BSG) is a polysaccharide extracted from basil seeds (*Ocimum basilicum L.*), which are commonly grown in India and Iran (Hosseini-Parvar et al., 2015). When soaked in water, the pericarp of basil seeds absorbs moisture and swells to form a gelatinous mass. BSG contains glucomannan (43 %) and (1/4)-linked xylan (24.3 %), with a gum content of 20 %, similar to other commercial hydrocolloids (Mirhosseini and Amid, 2013). Previous research has mainly focused on characterizing and improving the properties of BSG films (Hashemi Gahruie et al., 2019; 2020; Mohammad Amini et al., 2015), while its applications as a coating material have been limited to food products such as shrimps, strawberries, apricots (Hashemi et al., 2017; Khazaei et al., 2016; Moradi et al., 2019).

Consumer interest in healthy and biocompatible products, combined with consumer awareness of waste management issues and sustainable development, has contributed to the growing use of polymeric packaging to replace synthetic methods of food preservation (Oraç et al., 2023; Sabbah et al., 2019). Therefore, there has been great interest in the use of edible and biodegradable biopolymers as an environmentally safe substitute for materials derived from petroleum resources. Research has shown that edible coatings and films can protect the structure of food by acting as barriers to gases, solutes and oils, thereby extending shelf life by preventing oxidation, microbial growth and other forms of chemical degradation (Jafarzadeh et al., 2021). These materials also act as effective carriers for active ingredients such as antioxidants, antimicrobials and nutraceuticals (Costa et al., 2018). Due to these advantages, numerous studies have investigated the effects of edible films and coatings on different cheeses (Silva et al., 2022). In this context, zein (Ünalan et al., 2013), chitosan/whey (Yangilar, 2015), casein (Yangilar and Yildiz, 2016) and alginate-based coatings (Polat Yemiş et al., 2022) have been applied on Kashar cheese yielding positive results regarding shelf life. However, to the best of our knowledge, no studies have been published on the application of BSG-based coatings to Kashar cheese, making our study the first of its kind in this field. In a recent study, our research group comprehensively investigated the physical, thermal, barrier and microstructural properties of BSG-based films (Oraç et al., 2023). The results showed that the BSG-based films and coatings, when formulated with appropriate gum to glycerol ratios, can act as viable food packaging materials comparable to other biodegradable edible films. These findings formed the basis of the present investigation, which aims to evaluate edible films and coatings prepared with different concentrations of BSG, namely 0.5 %, 1.0 % and 1.5 %, combined with 1 %, 3 % and 5 % glycerol, for their influence on the physico-chemical, textural and microbiological status of Kashar cheese over a storage period of 60 days.

Material and methods

Material

The basil seeds (*Ocimum basilicum*) were provided by Arzuman Agro and Seed Company (Konya/Türkiye). Cow's milk was supplied by the Selcuk University, Faculty of Agriculture Farm (Konya, Türkiye). The rennet (Naturen-Mandra175/ 1:16.000) was obtained from Chr-Hansen (Hørsholm, Denmark), and the freeze-dried thermophilic lactic starter culture from Peyma-Chr-Hansen (Istanbul, Türkiye). NaOH, HCl, Ethanol (96 % v/v), Glycerol (95 % v/v), Mg $(NO_3)_2$, $CaCl_2$, Ringer Tablets, Plate Count Agar (PCA), Potato Dextrose Agar (PDA), M17 agar, De Man-Rogosa-Sharpe agar (MRS), Mueller Hinton Agar, Brain Heart Infusion (BHI) Broth were purchased from Merck Co. (Darmstadt, Germany). 2,2-diphenyl-1-picrylhydrazyl (DPPH) was obtained from Sigma-Aldrich (St. Louis, MO, USA). Antibacterial activity test microorganisms (*Listeria monocytogenes, Salmonella* Typhimurium, *Staphylococcus aureus, Escherichia coli,* and *Bacillus cereus*) were obtained from microbial collection of the Food Engineering Department of Selcuk University.

Extraction of gum

For the extraction and purification of BSG, the approach by Razavi et al. (2009) was adopted. First, basil seeds were washed 3-4 times with ethanol to remove impurities and then filtered and oven-dried at 50 °C to remove ethanol from the seed. The seeds were poured into 50-55 °C distilled water (seed: water ratio/1:30) which was adjusted to pH 8 using

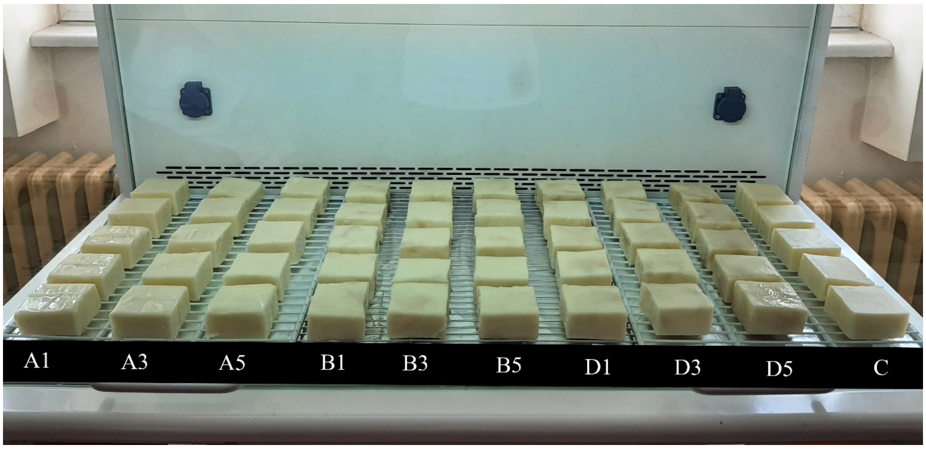

Figure 1. Samples of Kashar cheese coated with BSG-based coating. (A1, A3, A5: 0.5 % gum /1, 3, 5 % glycerol; B1, B3, B5: 1 % gum / 1, 3, 5 % glycerol; D1, D3, D5: 1.5 % gum / 1, 3, 5 % glycerol; C: control, uncoated sample)

0.2 M NaOH and HCl and stirred at 50 °C for 2 h with a magnetic stirrer (Lab ART/SH-5, Turkey). The dispersion was stirred at 1500 rpm for 10 min to remove the mucilage from the seed surface. After that, it was centrifuged at 9000 rpm for 15 min (Nüve-NF 800R, Türkiye) to separate the mucilage from the seed. The remaining mucilage on the upper phase was dried in the oven (Nüve KD 200, Türkiye) for 24 h at 50 °C.

Finally, dried mucilage was mixed with 95% ethanol (1:3 gum: ethanol) and left overnight at 4 °C to obtain the pure BSG. The gum solution was filtered with a kitchen sieve (200 mesh), and the sieve surface was washed using pure water to obtain all the gum from the sieve. Then, the solution was dried at 50 °C for 18 h and was ground. It was stored at +4 °C in plastic bags until used. The extraction yield of BSG was determined to be 20.2 % (Oraç et al., 2023).

Manufacturing of coating solutions and films

In the study, a total of 9 different coating solutions were prepared with 3 different gum (0.5, 1.0, and 1.5 %) and glycerol ratios (1, 3, and 5 %). Gum ratios were coded as A, B, and D; plasticizer ratios were coded as 1,3,5 and an uncoated sample was coded as C, respectively. In this context, BSG was added to distilled water at the concentrations indicated above and dissolved, and then a plasticizer was added. The solution was mixed thoroughly, and the pH was ensured to be 7 by adding HCl and NaOH. The prepared coating solutions were mixed using the hot plate at 50 °C for 2 h. Then, they were heat treated in a shaking water bath (DAIHAN-WISD-Maxturdy-30, South Korea) for 1 h at 80-85 °C for pasteurization. The air bubbles were removed by centrifugation of solutions at 6000 rpm for 5 min (Nüve-NF 800R, Türkiye), and the solutions were stored at +4 °C for 24 h. For the manufacturing of films, coating solutions were transferred to sterile Petri dishes (90 mm). Petri dishes were left open in an oven at 50 °C for 24 h, and the solutions were allowed to dry. Petri dishes were then placed in a desiccator containing saturated Mg $(NO_3)_2$ (53 % RH).

Kashar cheese production and coating of cheese samples

Kashar cheese production was carried out at the dairy pilot plant of the Food Engineering Department, at Selcuk University. The milk for the cheese production was pasteurized at 68 °C for 10 min and cooled to 32 °C. The pasteurized milk was inoculated with a starter culture (10 mL/kg), and then 2 mg/kg of $CaCl_2$ was added. After 30 min, when pH reached 6.30, milk was coagulated with calf rennet for 45 min. The curd was cut into 1 cm^3 cubes after about 30 min. Then, the coagulum was cooked for 30 min till 40 °C. After cooking, 1/3 portion of the whey was completely drained for 2 h. The curd was mixed gently until the pH reached 5.40. The pressed curd was cut into blocks and kept at room temperature until pH 5.05, then cut into smaller pieces. Then, each of the fresh cheeses was stretched at 75 °C in 8 % NaCl solution for 3 min. Plasticized cheese was put into rectangular molds. Cheese blocks were cooled at room temperature for 24 h (Yilmaz and Dagdemir, 2012).

The Kashar cheeses, which were divided into 200 g portions, were sterilized under UV light for 15 min in a laminar airflow sterile cabinet (Nüve/LN 120, Türkiye). The coating process was carried out by immersing the cheeses in the coating solution (1:3 cheese: coating solution) and leaving them in the solution for 2 min and removing them. The control group cheese sample was dipped in sterile distilled water and removed. The coated cheeses were left to dry in the cabin for 16-18 h (Figure 1). After drying, they were placed in sterile polyethylene zip-lock bags and kept at 4 °C throughout the ripening period.

Physicochemical analysis

The dry matter of the Kashar cheese samples was determined according to the Association of the Official Analytical Chemists (AOAC) (2016). The pH of the samples was measured using a WTW pH315 i / set brand digital pH meter. The water activity (a_w) of the Kashar cheese samples was determined using an Aqualab brand water activity meter (Decagon Devices Inc., Pullman, WA, USA). Approximately

20 g of the crust and interior of the cheese were placed in the sample reading chamber of the instrument. Three readings were taken for each sample. Changes in the surface color of the Kashar cheese samples were measured using a Minolta color meter (CR 400; Minolta, Japan). The color scale was assessed by the CIE L*a*b* color coordinate system (Artiga-Artigas et al., 2017). The weight of the cheese samples was weighed on the 1st, 7th, 15th, 30th and 60th day and the weight losses were determined using the method by Pena-Serna et al. (2016).

Microbiological enumerations

Cheese samples (10 g) from different groups were mixed homogeneously with sterile Ringer's solution (90 mL). Serial dilutions were then prepared from this dilution. The total number of mesophilic aerobic bacteria was determined on PCA agar after 48 h incubation at 37±1 °C. *Lactobacillus* counts were performed on MRS agar after 72 h incubation at 37±1 °C. M17 agar was used for the lactococcal count, and the Petri dishes were incubated for 48 h at 37±1 °C (Rençber et al., 2024). PDA agar (pH:3.5) was used for mold counting; it was incubated for 5-7 days at 23-25 °C. At the end of the incubation, the number of colonies was expressed in cfu/g.

Texture profile analysis

Texture Analyzer (TA.XT2, UK) was used for texture profile analysis. For this purpose, cheese samples were cut in 35x35x20 mm^3 dimensions and made ready for measurement. Working conditions of the device were: 36 mm diameter aluminum cylinder tip and 50 kg load cell, first test speed is 1 mm/s, and final test speed is 5 mm/s. In texture profile analysis, hardness, cohesiveness, chewiness, and springiness parameters were determined (Soltani et al., 2024).

DPPH radical scavenging activity of BSG-based films

The antioxidant activity determination of the prepared film samples was carried out by modifying the method determined by Kim et al. (2018). For this purpose, a film sample of 0.25 g was kept in 7.5 mL of distilled water at 37 °C for 1 h in a shaking condition. The prepared mixture was then centrifuged at 6500 rpm for 10 min, and the clear fraction was filtered. The obtained extracts (0.1 mL) were taken and mixed with 3.9 mL of methanolic DPPH (0.1 mM) solution and kept at room temperature for 1 h. The absorbances were measured in a spectrophotometer (Optizen 3220/ Korea) at a wavelength of 517 nm. The standard curve was constructed in terms of TEAC, and the results were expressed in mM TEAC/g.

Antibacterial activity of BSG-based films

The antibacterial activity of the BSG-based films was determined by the agar disc diffusion method. Each of the test microorganisms, *L. monocytogenes* ATCC 7644, *S.* Typhimurium ATCC 14028, *S. aureus* ATCC 25923, *E. coli* ATCC 25922 and *B. cereus* cultured in BHI broth (0.1 mL 10^6 cfu / mL) for 18 h was spread on Mueller-Hinton agar. Film samples of 15 mm diameter were prepared and placed aseptically on the agar in Petri dishes. The Petri dishes were kept at room temperature for 1 h and then incubated for 24 h at 37 °C. At the end of the incubation, the diameter of the zones formed around the films was measured with a caliper and expressed in mm.

Statistical analysis

A randomized two-level factorial experiment with three replicates for three factors was performed: BSG amount (0.5/1/1.5 %), plasticizer concentration (1/3/5 %), and ripening period (1, 7, 15, 30, 60 days). SPSS PASW 21.0 statistical software (USA) was used to perform analysis of variance (ANOVA) to determine statistical significance. Multiple comparisons of means were performed by Duncan's multiple comparison test at the 95 % confidence intervals ($p<0.05$).

Result and discussion

Physicochemical properties

The dry matter content of Kashar cheese ranged from 56.81 % to 58.00 % on day 1, with no significant differences between the coating treatments during the first 15 days (Table 1). At the end of storage, sample D5 had the highest dry matter (61.52 %). Similarly, Civelek and Cagri-Mehmetoglu (2019) reported stable dry matter values (55.50-58.90 %) in coated Kashar cheese, peaking at the end of storage without statistical significance. In contrast, Mei et al. (2013) found significant differences in dry matter between coated and uncoated Mongolian cheeses at the end of storage.

Table 1 shows the changes in weight of Kashar cheese during storage. The highest weight loss was found in the control sample with 0.168 g on day 60, while the lowest was found in the B5 sample with 0.093 g. Although no regular trend was observed with different ratios of plasticizer or gum, the differences were found to be statistically significant. In other similar studies, edible coatings were found to reduce moisture loss (Lima et al., 2021; Yangilar and Yildiz, 2016). On the other hand, in contrast to these results, Artiga-Artigas et al. (2017) reported that uncoated cheese had the lowest weight loss value compared to coated cheese.

Table 1. The effect of coating materials with different BSG and glycerol ratios on dry matter and weight loss of Kashar cheese samples

Dry matter						
		Ripening period (day)				
Gum ratio (%)	**Glycerol ratio (%)**	**1**	**7**	**15**	**30**	**60**
A	1	57.16±0.37^{A,c}	57.92±0.33^{A,bc}	58.85±0.49^{A,ab}	58.80±0.10^{AB,ab}	59.48±0.07^{B,a}
	3	56.81±0.09^{A,a}	59.08±1.88^{A,a}	58.70±0.11^{A,a}	59.21±0.33^{AB,a}	59.66±0.43^{B,a}
	5	57.29±0.03^{A,a}	59.27±2.07^{A,a}	58.05±0.07^{A,a}	59.33±0.31^{AB,a}	59.29±0.57^{B,a}
B	1	57.63±0.14^{A,b}	58.65±1.08^{A,ab}	57.50±0.10^{A,b}	59.22±0.53^{AB,ab}	60.44±0.04^{AB,a}
	3	56.86±0.47^{A,b}	58.36±1.22^{A,ab}	58.13±0.85^{A,ab}	58.95±0.10^{AB,ab}	59.98±0.07^{B,a}
	5	56.99±0.22^{A,c}	59.56±0.28^{A,ab}	57.75±0.81^{A,bc}	58.06±0.46^{AB,bc}	60.30±0.28^{AB,a}
D	1	58.00±0.48^{A,a}	58.92±0.46^{A,a}	57.07±1.38^{A,a}	59.23±0.28^{AB,a}	59.74±0.03^{B,a}
	3	56.94±0.15^{A,b}	59.49±0.27^{A,a}	57.08±1.08^{A,b}	59.88±0.18^{AB,a}	60.26±0.26^{AB,a}
	5	57.39±0.48^{A,c}	60.47±0.70^{A,ab}	58.98±0.86^{A,bc}	58.03±0.39^{B,c}	61.52±0.26^{A,a}
C		57.68±0.67^{A,a}	59.83±0.79^{A,a}	58.30±0.16^{A,a}	60.24±1.45^{A,a}	59.80±0.58^{B,a}
WeightlLoss						
A	1		0.047±0.000^{DE,d}	0.080±0.000^{B,c}	0.060±0.000^{C,b}	0.118±0.000^{BCD,a}
	3		0.082±0.001^{A,b}	0.063±0.001^{C,c}	0.070±0.002^{B,c}	0.122±0.005^{BCD,a}
	5		0.043±0.002^{DEF,c}	0.035±0.001^{FG,d}	0.060±0.001^{C,b}	0.150±0.002^{AB,a}
B	1		0.050±0.001^{D,c}	0.052±0.001^{D,c}	0.068±0.002^{B,b}	0.152±0.003^{AB,a}
	3		0.040±0.001^{EF,b}	0.036±0.002^{FG,b}	0.050±0.002^{D,b}	0.105±0.006^{CD,a}
	5		0.071±0.002^{B,c}	0.071±0.002^{A,a}	0.061±0.001^{C,d}	0.093±0.003^{A,b}
D	1		0.073±0.002^{B,b}	0.043±0.002^{E,b}	0.070±0.001^{B,b}	0.143±0.018^{ABC,a}
	3		0.043±0.005^{DEF,b}	0.039±0.001^{EF,b}	0.059±0.002^{C,b}	0.118±0.012^{BCD,a}
	5		0.037±0.002^{F,b}	0.032±0.002^{G,b}	0.042±0.003^{E,b}	0.153±0.023^{AB,a}
C			0.062±0.002^{C,c}	0.050±0.001^{D,c}	0.100±0.000^{A,b}	0.168±0.011^{A,a}

$^{a-d}$Different lower-case letters in the same row show statistical difference between ripening periods (p≤0.05). $^{A-G}$Different upper-case letters in the same column show statistical difference between samples (p≤0.05). A: 0.5 % gum, B: 1.0 % gum, D: 1.5 % gum, C: control/uncoated sample.

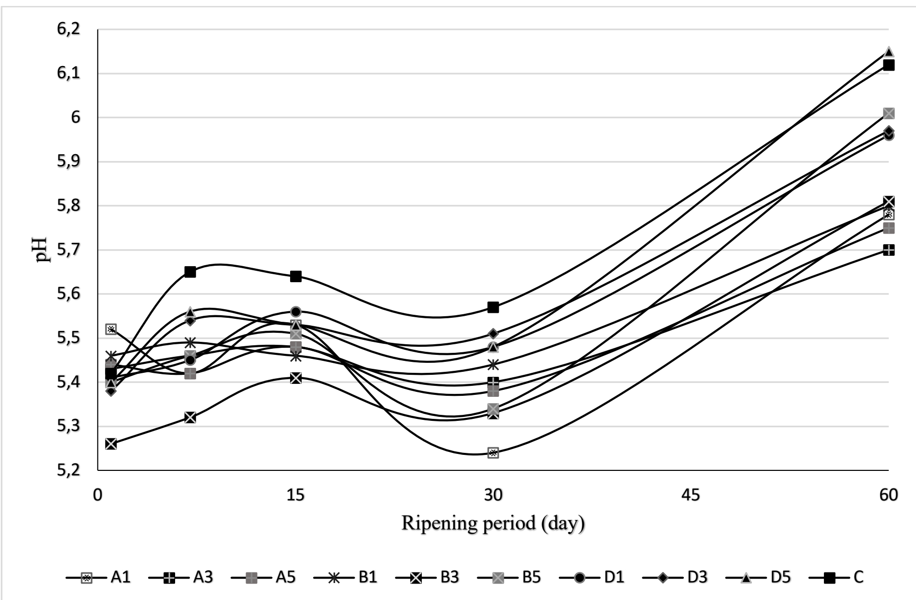

Figure 2. The effect of BSG-based coating materials on the pH of Kashar cheese samples (A1, A3, A5: 0.5 % gum /1, 3, 5 % glycerol; B1, B3, B5: 1 % gum / 1, 3, 5 % glycerol; D1, D3, D5: 1.5 % gum / 1, 3, 5 % glycerol; C: control, uncoated sample)

The pH values of the cheese samples during storage are shown in Figure 2. Different pH patterns were observed during storage of the cheese samples. Sample A had the highest initial pH level, but no consistent pattern was found as regarding gum content. Decrease in pH with an increase in gum was noticed in the case of samples containing 1 % glycerol (p<0.005), while other glycerol levels showed fluctuations in pH. By day 60, all samples had elevated pH values due to proteolysis, where lower pH was predicated in coated cheeses as compared to controls. Such pH variations

Table 2. The effect of coating material with different gum and glycerol ratios on water activity (aw) of Kashar cheese samples

Gum ratio (%)	Glycerol ratio (%)	1	7	15	30	60
		a_w (inner)				
		Ripening period (day)				
A	1	0.931±0.001^{DE,b}	0.946±0.001^{C,ab}	0.947±0.014^{A,ab}	0.964±0.001^{AB,a}	0.965±0.001^{A,a}
	3	0.959±0.001^{AB,a}	0.957±0.002^{BC,a}	0.959±0.001^{A,a}	0.961±0.001^{BC,a}	0.961±0.001^{AB,a}
	5	0.964±0.001^{A,a}	0.951±0.002^{BC,bc}	0.957±0.002^{A,b}	0.953±0.002^{DE,bc}	0.948±0.001^{C,c}
B	1	0.952±0.003^{ABC,b}	0.961±0.001^{AB,a}	0.951±0.001^{A,b}	0.950±0.001^{E,b}	0.951±0.001^{C,b}
	3	0.965±0.004^{A,ab}	0.971±0.002^{A,a}	0.950±0.006^{A,c}	0.956±0.002^{CD,bc}	0.955±0.001^{BC,bc}
	5	0.963±0.004^{AB,a}	0.954±0.006^{BC,a}	0.960±0.002^{A,a}	0.964±0.002^{AB,a}	0.955±0.004^{BC,a}
D	1	0.943±0.004^{CD,b}	0.973±0.004^{A,a}	0.963±0.004^{A,a}	0.961±0.001^{BC,a}	0.934±0.001^{D,b}
	3	0.951±0.002^{BC,a}	0.955±0.006^{BC,a}	0.949±0.001^{A,a}	0.960±0.001^{BC,a}	0.946±0.005^{C,a}
	5	0.924±0.007^{E,b}	0.962±0.004^{AB,a}	0.947±0.002^{A,a}	0.959±0.001^{BC,a}	0.949±0.002^{C,a}
C		0.921±0.001^{E,d}	0.960±0.002^{ABC,b}	0.949±0.001^{A,c}	0.969±0.001^{A,a}	0.947±0.002^{C,c}
		a_w (outer)				
A	1	0.929±0.001^{C,c}	0.941±0.004^{F,bc}	0.936±0.006^{C,c}	0.953±0.001^{ABC,b}	0.973±0.004^{A,a}
	3	0.943±0.004^{A,b}	0.945±0.001^{DEF,b}	0.954±0.001^{AB,a}	0.960±0.001^{A,a}	0.960±0.002^{BC,a}
	5	0.941±0.002^{A,c}	0.947±0.001^{BCDEF,bc}	0.951±0.001^{B,b}	0.947±0.003^{CD,bc}	0.964±0.001^{B,a}
B	1	0.944±0.003^{A,b}	0.943±0.001^{EF,b}	0.948±0.001^{B,b}	0.942±0.002^{D,b}	0.967±0.003^{AB,a}
	3	0.925±0.001^{C,d}	0.946±0.004^{CDEF,c}	0.954±0.001^{AB,b}	0.950±0.001^{BCD,bc}	0.965±0.001^{AB,a}
	5	0.932±0.002^{BC,c}	0.950±0.001^{BCDE,b}	0.949±0.001^{B,b}	0.956±0.004^{AB,ab}	0.961±0.001^{B,a}
D	1	0.941±0.001^{A,b}	0.951±0.001^{BCD,a}	0.951±0.001^{B,a}	0.951±0.001^{ABC,a}	0.949±0.001^{D,a}
	3	0.938±0.001^{AB,c}	0.953±0.001^{BC,b}	0.963±0.001^{A,a}	0.948±0.001^{BCD,b}	0.952±0.001^{CD,b}
	5	0.902±0.002^{E,d}	0.961±0.001^{A,a}	0.953±0.001^{B,b}	0.954±0.001^{ABC,b}	0.933±0.001^{E,c}
C		0.916±0.001^{D,c}	0.954±0.001^{B,a}	0.945±0.004^{BC,a}	0.946±0.004^{CD,a}	0.927±0.002^{E,b}

a-d Different lower-case letters in the same row show statistical difference between ripening periods (p≤0.05). A-F Different upper-case letters in the same column show statistical difference between samples (p≤0.05). A: 0.5 % gum, B: 1.0 % gum, D: 1.5 % gum, C: control/uncoated sample.

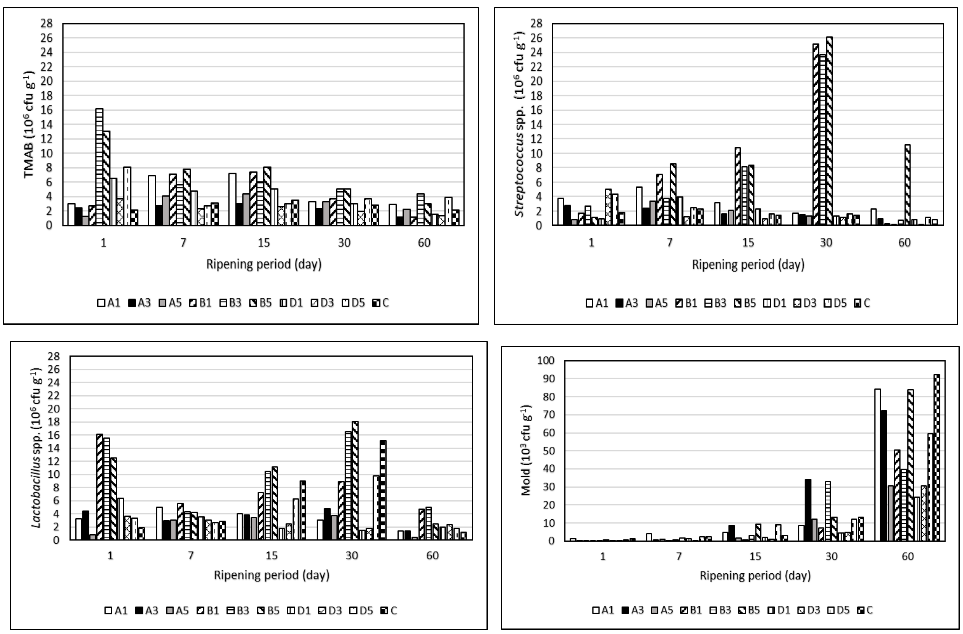

Figure 3. The effect of BSG-based coatings on the total mesophilic aerobic bacteria (TMAB), presumptive lactobacilli, streptococci, and mold counts of Kashar cheese samples throughout the ripening period. (A1, A3, A5: 0.5 % gum /1, 3, 5 % glycerol; B1, B3, B5: 1 % gum / 1, 3, 5 % glycerol; D1, D3, D5: 1.5 % gum / 1, 3, 5 % glycerol; C: control, uncoated sample)

were also reported in previous studies on Gouda and Kashar cheeses (Berti et al., 2019; Yilmaz and Dagdemir, 2012).

Water activity of Kashar cheese samples during storage is presented in Table 2. On day 1, the lowest inner a_w values were in the C and D5 samples. No linear increase or decrease in a_w values was detected during storage. At the end, the lowest outer a_w value was in the C sample, while the coated samples had higher outer a_w values, indicating lower water loss compared to the control. Coating materials were effective in minimizing water loss. Contrarily, Polat Yemiş et al. (2022) reported a steady a_w value in Kashar cheese coated with nano emulsion-based sodium alginate.

The effects of coating treatment and ripening time on the color values of Kashar cheeses are given in Table 3.

Table 3. The effect of coating materials with different BSG and glycerol ratios on the color values of Kashar cheese samples

Gum ratio (%)	Glycerol ratio (%)	1	7	15	30	60
		Ripening period (day)				
L* value						
A	1	68.39±0.76^{A,ab}	67.62±1.25^{AB,ab}	65.50±0.17^{CD,b}	69.31±1.46^{BC,ab}	70.74±1.61^{AB,a}
	3	66.69±1.10^{A,ab}	66.60±1.40^{AB,ab}	68.44±0.17^{ABC,a}	69.45±0.03^{BC,a}	64.07±1.15^{C,b}
	5	67.58±0.38^{A,b}	68.23±0.97^{A,b}	69.89±0.01^{A,b}	69.22±1.18^{BC,b}	73.00±0.68^{A,a}
B	1	67.02±1.31^{A,b}	67.27±1.02^{AB,ab}	67.92±0.13^{ABC,ab}	70.53±1.91^{AB,ab}	71.69±0.37^{AB,a}
	3	66.01±0.92^{A,bc}	67.93±0.08^{AB,ab}	63.57±1.41^{D,c}	67.84±0.64^{BC,ab}	69.78±0.86^{AB,a}
	5	67.14±0.69^{A,ab}	65.94±0.45^{AB,b}	67.79±0.47^{ABC,ab}	69.38±1.67^{BC,a}	69.45±0.09^{B,a}
D	1	68.35±0.87^{A,a}	66.40±0.20^{AB,a}	67.94±1.84^{ABC,a}	68.27±0.33^{BC,a}	68.58±0.70^{B,a}
	3	66.94±1.53^{A,a}	67.48±1.75^{AB,a}	66.80±0.31^{ABCD,a}	65.43±0.23^{C,a}	68.98±0.84^{B,a}
	5	65.97±1.03^{A,ab}	64.37±0.43^{B,b}	65.83±1.09^{BCD,ab}	65.55±1.08^{C,ab}	69.41±1.08^{B,a}
C		67.09±0.56^{A,b}	67.65±0.44^{AB,b}	68.97±0.17^{AB,b}	74.11±0.73^{A,a}	68.66±0.53^{B,b}
a* value						
A	1	-6.06±0.25^{CDE,a}	-6.18±0.09^{AB,a}	-7.02±0.10^{B,b}	-6.71±0.18^{B,ab}	-6.12±0.25^{A,a}
	3	-5.42±0.01^{ABCD,a}	-6.02±0.33^{AB,a}	-6.11±0.42^{AB,a}	-6.42±0.26^{B,a}	-6.33±0.08^{A,a}
	5	-6.13±0.14^{CDE,a}	-6.33±0.45^{B,a}	-6.34±0.10^{AB,a}	-6.28±0.12^{B,a}	-6.20±0.26^{A,a}
B	1	-5.57±0.29B^{CDE,a}	-5.86±0.20^{AB,a}	-6.29±0.40^{AB,a}	-6.14±0.28^{B,a}	-5.63±0.24^{A,a}
	3	-4.66±0.45^{AB,a}	-6.15±0.18^{AB,b}	-6.55±0.57^{AB,b}	-5.90±0.02^{B,ab}	-5.81±0.07^{A,ab}
	5	-5.99±0.08^{CDE,a}	-5.69±0.33^{AB,a}	-6.27±0.10^{AB,a}	-5.64±0.74^{AB,a}	-5.40±0.62^{A,a}
D	1	-6.46±0.11^{E,b}	-5.63±0.06^{AB,a}	-6.19±0.31^{AB,ab}	-5.92±0.20^{B,ab}	-5.77±0.13^{A,ab}
	3	-5.16±0.22^{ABC,a}	-6.07±0.04^{AB,ab}	-6.75±0.01^{B,b}	-5.62±0.44^{AB,a}	-5.94±0.23^{A,ab}
	5	-4.56±0.46^{A,a}	-5.38±0.06^{A,ab}	-5.54±0.09^{A,b}	-4.63±0.01^{A,a}	-5.55±0.10^{A,b}
C		-6.19±0.01^{DE,ab}	-6.52±0.08^{B,a}	-6.42±0.04^{AB,b}	-6.54±0.00^{B,b}	-5.87±0.28^{A,b}
b* value						
A	1	33.60±0.00^{A,a}	28.75±0.59^{A,ab}	26.34±2.84^{A,b}	27.28±1.08^{AB,b}	27.48±0.21^{A,b}
	3	33.64±2.00^{A,a}	27.83±0.50^{A,b}	27.03±2.12^{A,b}	28.56±0.35^{A,ab}	27.12±1.03^{A,b}
	5	33.64±0.59^{A,a}	27.75±1.23^{A,b}	26.38±0.19^{A,b}	23.82±1.27^{B,b}	24.29±1.19^{A,b}
B	1	32.35±1.15^{A,a}	27.62±0.26^{A,ab}	24.02±1.29^{A,b}	25.36±1.49^{AB,b}	26.95±2.13^{A,ab}
	3	32.57±0.39^{A,a}	27.64±0.11^{A,b}	24.12±1.25^{A,b}	26.15±0.67^{AB,b}	25.02±1.82^{A,b}
	5	35.58±0.90^{A,a}	27.51±0.08^{AB,b}	26.40±0.25^{A,b}	25.13±1.04^{AB,b}	26.48±2.19^{A,b}
D	1	35.69±1.33^{A,a}	25.33±0.04^{B,b}	26.33±0.73^{A,b}	25.06±2.34^{AB,b}	26.00±0.21^{A,b}
	3	34.61±0.01^{A,a}	26.71±0.15^{AB,b}	24.81±0.10^{A,b}	24.84±1.12^{AB,b}	27.66±1.92^{A,b}
	5	33.45±0.59^{A,a}	27.02±0.87^{AB,b}	25.95±2.45^{A,b}	24.58±0.76^{AB,b}	25.05±0.76^{A,b}
C		34.38±0.26^{A,a}	26.63±0.43^{AB,c}	25.60±0.59^{A,c}	28.80±0.24^{A,b}	23.70±0.28^{A,d}

$^{a-d}$Different lower-case letters in the same row show statistically the difference between ripening periods (p≤0.05). $^{A-E}$Different upper-case letters in the same column show statistically the difference between samples (p≤0.05). A: 0.5 % gum, B: 1.0 % gum, D: 1.5 % gum, C: control/uncoated sample.

No significant relationship was found between the addition of gum and the brightness (L*) of the cheeses. The L* values of all samples increased during storage, except for the uncoated sample. Civelek and Cagri-Mehmetoglu (2019) found an increase in L* values during storage of coated Kashar cheese, while Pena-Serna et al. (2016) found that coating reduced the brightness of Minas-Padro cheese. Throughout storage, A* values remained negative (green), with no significant changes related to gum or glycerol ratio, in agreement with the findings by Berti et al. (2019). At the end of storage, a 31 % decrease in yellow discoloration was observed in sample C, with the highest b* value in sample B3. Yellowness was lower in all coated cheeses compared to the control.

Microbiological enumerations of Kashar cheeses

Assessment of the influence of the BSG coating on the microbial quality of the Kashar cheese was executed by counting the total mesophilic aerobic bacteria (TMAB), presumptive lactobacilli, presumptive streptococci, and mold (Figure 3). After 60 days of storage, a reduction in TMAB was observed in all samples except for the control and A5. In each BSG concentration (A, B, D), lower and higher TMAB counts were found compared to the control, indicating that no specific gum ratio improves microbial quality. Cerqueira et al. (2010) reported the highest TMAB in galactomannan-coated cheese. However, some studies did not find significant differences in TMAB between coated and uncoated cheeses (Lucera et al., 2014; Yilmaz and Dagdemir, 2012). A3, B1 and D3 coatings showed the best preservation.

Throughout the storage, fluctuations were observed in presumptive lactobacilli and streptococci counts in coated and uncoated Kashar cheeses. Coating material is not expected to negatively affect lactic acid bacteria (LAB), which contribute to the ripening process, influence the formation of desired aroma changes, and preserve the products (Lucera et al., 2014). In this study, final streptococci and lactobacilli counts in M17 and MRS did not differ significantly between BSG-coated and uncoated cheeses, except for the B5 sample in M17 and A5 in MRS. These results align with Yilmaz and Dagdemir (2012), and Pourmolaie et al. (2018), who found similar outcomes in their studies. Higher streptococci counts were noted in A1, A3, and D1 samples, and higher lactobacilli counts in B3 and B5 samples compared to the control. Thus, BSG coating did not adversely affect the microbial balance and may even enhance LAB bioactivity. Gums and mucilage from the cell wall of different plant parts have a heteropolysaccharide structure comprising two or more repeating units of fermentable sugars (Olawuyi et al., 2021). This structure is therefore thought to enhance the growth of LAB together with the appropriate oxygen, pH, and moisture conditions when these polysaccharides are used in the coating.

The mold count increased in all cheese samples during storage. The best protection of the cheese against mold was observed in samples B1, D1 and D3 up to day 30. By day 60, all the coated cheese samples showed lower mold loads than the uncoated cheeses, with the lowest counts found in samples D1, A5, D3 and B3. These results are in agreement with Yilmaz and Dagdemir (2012), although the mold counts were relatively lower than in the present study. This could be due to higher O2 concentrations in BSG-coated cheeses compared to wax-coated cheeses. Similar results were obtained by Yangilar (2015), who reported that edible films such as chitosan/whey protein suppressed mold growth. The results indicate that a coating of 1.5 % BSG combined with 1 % and 3 % glycerol (D1, D3) serves as an effective biomaterial to reduce mold load in Kashar cheese.

Texture profile analysis of Kashar cheeses

On the first day of storage, the highest hardness value was obtained in the BSG-coated cheeses with the highest gum/glycerol ratio. The uncoated cheese sample also had the lowest hardness value. Although statistically insignificant increases or decreases occurred in all samples during storage (Table 4) except for A3, B1 and B3, the hardness value of the coated samples was higher than that of the control sample at the end of storage. Several researchers reported an increase in hardness due to storage conditions in their studies where they applied edible coatings to different cheeses, in parallel with our results (Berti et al., 2019; Cerqueira et al., 2010).

No statistically significant changes were observed in the springiness values of Kashar cheeses from day 1 to day 30 (Table 4). At the end of storage, the highest springiness values were found in samples with 3 % glycerol across all gum concentrations. Although a decrease in springiness was observed in all samples on the last day, only three samples showed a statistically significant decrease. Sabbah et al. (2019) reported no significant difference in springiness between coated and uncoated samples, while Korish and Abd Elhamid (2012) reported lower springiness in coated cheeses compared to the control.

Cohesiveness decreased in all samples towards day 60. Baghdadi et al. (2018) reported similar findings, noting the lowest cohesiveness values at the end of storage in their cheese studies. In this study, the cohesiveness value of the control was lower than BSG-coated samples, except for B5 and A3, with the highest value in A1 (Table 4). Pena-Serna et al. (2016) found that biodegradable coatings provided more cohesive Minas Padro cheese than the control, similar to our findings. The researchers attributed this increase to the formation of a 3D gel structure by gums and potent interactions amongst gums and the other food components.

The chewiness values in all samples were found to be lower on the 60th day of storage than on the first day of storage (Table 4). Aydın and Tarakçı (2021)reported that the chewiness values of all samples were lower at the end of storage than at the beginning of storage in their study on Kashar cheese, in parallel with our results. At the end of storage, D3 and A1 cheeses had the highest chewiness values among all, while those of B1, B3, and B5 cheese samples were lower than that of the control cheese.

DPPH scavenging activity changes in BSG-based films

Plant seed polysaccharides-based hydrocolloids are used in food and pharmaceutical industries due to their favorable functional properties, including fiber, mucoadhesive properties, and antioxidant activities (Arab et al., 2021). The antioxidant activity of films prepared from BSG, evaluated by the DPPH free radical scavenging method, was between 6.99- and 76.47-mM TEAC/g (Figure 4). A higher glycerol content led to a significant decrease in the antioxidant activity of films ($p<0.05$). This decline may be due to the reduced solubility of antioxidant components in BSG, which has high antioxidant content, as glycerol reduces water content in the film (Uma Devi, 2001). Basil seeds produce a gelatinous mucilage that swells in water, and the solubility of this mucilage, affecting antioxidant activity, is influenced by the water content of the medium. Guidara et al. (2019) investigated the effect of different extraction methods and plasticizer concentrations on ulvan films and reported that the DPPH radical scavenging activity of all films decreased significantly with increasing plasticizer concentration, in parallel with our results. On the contrary, Díaz et al. (2019) used different concentrations of glycerol in chickpea flour-based films and observed that DPPH scavenging activity increased with increasing concentration.

The antioxidant activities of the films were significantly affected by the amount of BSG. In our study, as the gum ratio increased from 0.5 % to 1.5 %, the DPPH radical scavenging activity mean values also increased. Different studies report that BSG has a high antioxidant potential (Nourozi and Sayyari, 2020). In a recent study conducted by Kim et al. (2020), BSG powder addition presented an improvement in antioxidant activity, and the total phenolic content of

Table 4. The effect of coating materials with different BSG and glycerol ratios on the textural properties of Kashar cheese samples

Hardness						
		Ripening period (day)				
Gum ratio (%)	Glycerol ratio (%)	1	7	15	30	60
A	1	40448±4111^{ABC,a}	33649±695^{A,a}	49133±991^{A,a}	42382±4565^{A,a}	44922±8012^{CD,a}
	3	40659±648^{ABC,a}	33634±3188^{A,bc}	34083±186^{BC,abc}	30751±1721^{AB,c}	39797±616^{D,ab}
	5	46179±3581^{AB,a}	30997±1328^{AB,c}	37068±2451^{BC,bc}	32902±2614^{AB,c}	60388±3076^{AB,a}
B	1	36272±2163^{BCD,ab}	31256±404^{AB,c}	32062±1302^{C,bc}	31921±1044^{AB,ac}	39974±372^{D,a}
	3	35597±366^{CD,a}	31047±1608^{AB,a}	32103±5457^{C,a}	32544±205^{AB,a}	41491±1182^{CD,a}
	5	37895±1288^{BCD,b}	25219±339^{C,c}	31787±3469^{C,bc}	31022±374^{AB,c}	51949±218^{BC,a}
D	1	34284±4651^{CD,b}	24269±512^{C,b}	35944±1334^{BC,b}	36322±7749^{AB,a}	58688±1631^{AB,a}
	3	32356±2156^{CD,b}	30870±1105^{AB,a}	31669±4614^{C,b}	37553±1123^{AB,a}	64705±1814^{A,a}
	5	49223±971^{A,a}	28241±341^{BC,c}	43779±847^{AB,a}	30048±882^{B,c}	45805±730^{CD,b}
C		29999±161^{D,c}	32009±381^{AB,c}	35159±3416^{BC,bc}	39455±41.7^{AB,ab}	41744±866^{CD,a}
Springiness						
A	1	0.843±0.031^{A,a}	0.857±0.006^{A,a}	0.880±0.017^{A,a}	0.871±0.104^{A,a}	0.750±0.001^{BC,a}
	3	0.863±0.004^{A,a}	0.853±0.060^{A,a}	0.834±0.016^{A,a}	0.759±0.013^{A,a}	0.792±0.005^{AB,a}
	5	0.870±0.010^{A,a}	0.890±0.000^{A,a}	0.807±0.001^{A,c}	0.837±0.006^{A,b}	0.733±0.005^{CD,d}
B	1	0.845±0.004^{A,a}	0.816±0.037^{A,a}	0.795±0.013^{A,a}	0.826±0.007^{A,a}	0.690±0.000^{DE,b}
	3	0.864±0.003^{A,a}	0.876±0.017^{A,a}	0.793±0.011^{A,a}	0.848±0.048^{A,a}	0.822±0.003^{A,a}
	5	0.848±0.001^{A,a}	0.820±0.029^{A,a}	0.829±0.018^{A,a}	0.869±0.033^{A,a}	0.670±0.003^{E,b}
D	1	0.846±0.007^{A,a}	0.860±0.059^{A,a}	0.819±0.040^{A,a}	0.747±0.032^{A,a}	0.751±0.045^{BC,a}
	3	0.850±0.006^{A,a}	0.862±0.012^{A,a}	0.849±0.018^{A,a}	0.817±0.033^{A,a}	0.848±0.003^{A,a}
	5	0.854±0.080^{A,a}	0.787±0.041^{A,a}	0.832±0.031^{A,a}	0.777±0.041^{A,a}	0.807±0.006^{AB,a}
C		0.877±0.029^{A,a}	0.866±0.039^{A,a}	0.871±0.091^{A,a}	0.784±0.061^{A,a}	0.839±0.005^{A,a}
Cohesiveness						
A	1	0.673±0.02^{A,ab}	0.742±0.03^{A,a}	0.569±0.05^{A,bc}	0.601±0.01^{ABC,bc}	0.513±0.01^{A,c}
	3	0.700±0.01^{A,ab}	0.734±0.01^{A,a}	0.621±0.02^{A,bc}	0.609±0.03^{AB,c}	0.349±0.03^{EF,d}
	5	0.668±0.03^{A,ab}	0.705±0.02^{A,a}	0.602±0.02^{A,b}	0.627±0.01^{AB,a}	0.410±0.00^{BCD,c}
B	1	0.683±0.00^{A,ab}	0.720±0.00^{A,a}	0.580±0.03^{A,c}	0.650±0.00^{A,b}	0.430±0.00^{BC,d}
	3	0.644±0.03^{A,ab}	0.716±0.01^{A,a}	0.626±0.01^{A,b}	0.511±0.01^{C,c}	0.418±0.03B^{CD,d}
	5	0.684±0.04^{A,ab}	0.720±0.01^{A,a}	0.605±0.01^{A,bc}	0.563±0.03^{ABC,c}	0.312±0.00^{F,d}
D	1	0.669±0.02^{A,b}	0.726±0.01^{A,a}	0.620±0.00^{A,b}	0.558±0.00^{BC,c}	0.405±0.01^{BCDE,d}
	3	0.715±0.01^{A,a}	0.734±0.03^{A,a}	0.618±0.05^{A,ab}	0.561±0.04^{ABC,b}	0.381±0.01^{CDE,c}
	5	0.698±0.05^{A,ab}	0.724±0.04^{A,a}	0.654±0.03^{A,ab}	0.568±0.03^{ABC,bc}	0.452±0.01^{B,c}
C		0.695±0.02^{A,a}	0.752±0.01^{A,a}	0.791±0.16^{A,a}	0.640±0.02^{AB,ab}	0.366±0.01^{DEF,b}
Chewiness						
A	1	22906±2268^{AB,a}	20972±48^{A,a}	24644±3102^{A,a}	22048±577^{A,a}	19913±130^{A,a}
	3	24558±96^{AB,a}	21151±3841^{A,ab}	21058±780^{A,ab}	14208±46^{B,bc}	12083±688^{C,c}
	5	26794±457^{AB,a}	20729±433^{A,a}	20506±5241^{A,a}	17255±1445^{AB,a}	18081±1166^{AB,a}
B	1	23808±5452^{AB,a}	18374±1162^{AB,ab}	15981±116^{A,ab}	16900±1135^{AB,ab}	11919±166^{C,b}
	3	19787±561^{AB,a}	19474±1019^{AB,a}	15933±2659^{A,ab}	14303±1431^{B,ab}	10921±418^{C,b}
	5	21991±2062^{AB,a}	15828±307^{AB,a}	15907±1168^{A,b}	12753±550^{B,bc}	10824±200^{C,c}
D	1	18211±145^{B,ab}	14424±502^{B,b}	19643±388^{A,a}	15069±2461^{AB,ab}	16969±561^{B,ab}
	3	20750±359^{AB,a}	19519±221^{AB,a}	16754±4185^{A,a}	17189±1051^{AB,a}	20216±891^{A,a}
	5	29450±5369^{A,a}	17778±314^{AB,a}	22991±158^{A,ab}	13306±1904^{B,b}	16325±384^{B,b}
C		21560±699^{AB,a}	20846±1403^{A,a}	24102±5069^{A,a}	17333±4241^{AB,a}	16151±266^{B,a}

$^{a-d}$Different lower-case letters in the same row show statistically the difference between ripening periods ($p \leq 0.05$). $^{A-F}$Different upper-case letters in the same column show statistically the difference between samples ($p \leq 0.05$). A: 0.5 % gum, B: 1.0 % gum, D: 1.5 % gum, C: control/uncoated sample.

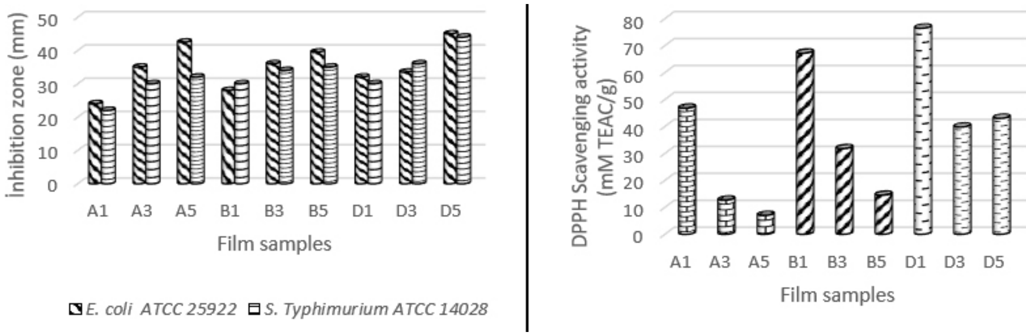

Figure 4. Effect of different BSG and glycerol concentrations on antimicrobial and antioxidant properties of BSG-based film samples (A1, A3, A5: 0.5 % gum /1, 3, 5 % glycerol; B1, B3, B5: 1 % gum / 1, 3, 5 % glycerol; D1, D3, D5: 1.5 % gum / 1, 3, 5 % glycerol).

yoghurt is consistent with our data. BSG is already known for its enhanced levels of phenolic acids, which contribute to antioxidant activity (Kim et al., 2020).

Determination of antibacterial activity effects of BSG-based film on Kashar cheeses

Recently, food-borne microbial epidemics and diseases, and the search for quality, freshness, and safety in foods have increased the search for innovative ways to prevent microbial growth. One of the options is to design food packaging with antimicrobial properties. These packaging technologies can play an important role in food preservation, especially in reducing the risk of pathogenic microorganisms. The inhibitory effect of BSG-based films against test microorganisms is shown in Figure 4. While no inhibitory effect was observed against *L. monocytogenes* ATCC 7644, *S. aureus* ATCC 25923, and *B. cereus*, the inhibition zones against *E. coli* ATCC 25922 and *S.* Typhimurium ATCC 14028 ranged between 24-45 mm and 22-44 mm, respectively.

The cell wall structure and composition are different between Gram-positive and Gram-negative bacteria. Gram-negative bacteria have an outer membrane that contains lipopolysaccharides, which some plant polysaccharides can diffuse through, showing stronger antibacterial activity against Gram-negative bacteria (Zhou et al., 2022). Some studies have demonstrated that polysaccharides from pumpkin seeds and hypericum leaves exhibit better antibacterial activity against Gram-negative bacteria, including *E. coli* ATCC 25922 and *S.* Typhimurium ATCC 14028, in contrast with Gram-positive bacteria, may be explained by this mechanism and can account for their increased susceptibility to basil seed-derived polysaccharides (Heydarian et al., 2017; Wang et al., 2017).

For both species, the inhibitory effect increased as the gum and glycerol concentrations increased ($p<0.05$). Diameter zone measurements were within the range of 14.33 mm to 27.66 mm. Similarly, the antimicrobial properties of films made from sago starch and guar gum against *B. cereus* and *E. coli* were demonstrated by Dhumal et al. (2019). Based on the above considerations, the efficacy of BSG films against *E. coli* and *S.* Typhimurium suggests their potential use as antimicrobial packaging. In parallel to our study, Moradi et al. (2019) and Olawuyi et al. (2021) also reported that basil seed mucilage was effective as an antimicrobial agent without the addition of essential oil.

Conclusion

In the current study, nine different film/coating solutions were prepared using three different gum concentrations (0.5 %, 1.0 % and 1.5 %) and glycerol ratios (1 %, 3 % and 5 %). The highest dry matter content and the lowest weight loss were observed in cheeses coated with 1.5 % gum + 5 % glycerol (D5) and 1 % gum + 5 % glycerol (B5) compared to the control. The lowest recorded a_w value was obtained for the uncoated sample at day 60. Although no inhibition was observed for BSG on Gram-positive bacteria, it exhibited antibacterial activity on both *E. coli* ATCC 25922 and *S.* Typhimurium ATCC 14028. The application of BSG coating and different levels of glycerol did not adversely affect the survival rate of presumptive lactobacilli and streptococci in most cheese samples throughout the storage period. Coated cheeses had significantly higher brightness values than uncoated cheeses. However, higher glycerol concentrations significantly decreased the DPPH scavenging activities of BSG films, whereas higher gum concentrations increased these activities. At the end of storage, D3 coated cheeses (1.5 % gum + 3 % glycerol) had the highest hardness, chewiness and springiness. The findings suggest that BSG-based coatings positively contributed to extending shelf life and preserving the quality of Kashar cheese. Furthermore, increasing gum concentration enhanced these effects. Future studies should focus on improving the barrier and antimicrobial properties of BSG coatings, particularly through the incorporation of essential oils, bioactive compounds, and nanomaterials.

Acknowledgements

We are grateful to Selçuk University Scientific Research Projects Coordinatorship for providing financial support to this research (Grant number 20401023).

Poboljšanje kvalitete i roka trajanja sira Kashar korištenjem premaza i filmova na bazi gume od sjemenki bosiljka

Sažetak

Sustavi za pakiranje sira igraju ključnu ulogu u sprječavanju neželjenih reakcija i nedostataka sira tijekom procesa zrenja. Potražnja potrošača za zdravim i prirodnim proizvodima dramatično se povećala posljednjih godina. Radi toga na važnosti su dobili biorazgradivi i jestivi materijali za pakiranje. Nedavne studije ukazale su na zelene alternative, uglavnom prirodne polimere, umjesto konvencionalnog pakiranja sireva na bazi plastike. Ovaj rad istražuje učinkovitost gume bosiljka, kao jestivog filma i materijala za premazivanje, u očuvanju fizikalno-kemijskih, mikrobioloških, teksturalnih i antioksidativnih svojstava sira Kashar tijekom 60 dana skladištenja. Pripremljeno je devet otopina za premazivanje s različitim koncentracijama gume (0,5 %, 1,0 %, 1,5 %) i plastifikatora (1 %, 3 %, 5 %). Premazi na bazi gume bosiljka smanjili su gubitak težine, inhibirali rast *Escherichia coli* i *Salmonella Typhimurium* te povećali antioksidativnu aktivnost sira. S povećanjem koncentracije gume, djelovanje je bilo jače. Tekstualna i mikrobiološka svojstva također su poboljšana, poboljšavajući rok trajanja i kvalitetu sira.

Ključne riječi: sir Kashar; guma bosiljka; premaz; jestivi film; zrenje

References

1. Al-Tayyar, N. A., Youssef, A. M., Al-hindi, R. (2020): Antimicrobial food packaging based on sustainable Bio-based materials for reducing foodborne Pathogens: A review. *Food Chemistry* 310.
https://doi.org/10.1016/j.foodchem.2019.125915
2. Arab, K., Ghanbarzadeh, B., Ayaseh, A., Jahanbin, K. (2021): Extraction, purification, physicochemical properties and antioxidant activity of a new polysaccharide from *Ocimum album* L. seed. *International Journal of Biological Macromolecules* 180, 643-653.
https://doi.org/10.1016/J.IJBIOMAC.2021.03.088
3. Artiga-Artigas, M., Acevedo-Fani, A., Martín-Belloso, O. (2017): Improving the shelf life of low-fat cut cheese using nanoemulsion-based edible coatings containing oregano essential oil and mandarin fiber. *Food Control* 76, 1-12.
https://doi.org/10.1016/j.foodcont.2017.01.001
4. Association of the Official Analytical Chemists (AOAC) (2016): Official Methods of Analysis of AOAC International - 20th Edition, *Gaithersburg: AOAC.*
5. Aydın, E., Tarakçı, Z. (2021): Effects of different types of herbs on colour and texture properties of Kashar cheese. *Food and Health* 7, 120-127.
https://doi.org/10.3153/FH21013
6. Baghdadi, F., Aminifar, M., Farhoodi, M., Shojaee, S. (2018): Changes in the structure of brined cheese modified with basil seed gum based on protein-polysaccharide interactions. *Journal of Agricultural Science and Technology* 20, 695-708.
http://jast.modares.ac.ir/article-23-19842-en.html
7. Berti, S., Ollé Resa, C.P., Basanta, F., Gerschenson, L.N., Jagus, R.J. (2019): Edible coatings on Gouda cheese as a barrier against external contamination during ripening. *Food Bioscience* 31, 100447.
https://doi.org/10.1016/J.FBIO.2019.100447
8. Cerqueira, M.A., Sousa-Gallagher, M.J., Macedo, I., Rodriguez-Aguilera, R., Souza, B.W. S., Teixeira, J.A., Vicente, A.A. (2010): Use of galactomannan edible coating application and storage temperature for prolonging shelf-life of “Regional” cheese. *Journal of Food Engineering* 97, 87-94.
https://doi.org/10.1016/J.JFOODENG.2009.09.019
9. Civelek, I., Cagri-Mehmetoglu, A. (2019): Determination of antifungal effect of edible Coatings Containing *Williopsis saturnus var. saturnus* against yeast and mold growth on Kashar cheese. *Journal of Food Science* 84, 311-318.
https://doi.org/10.1111/1750-3841.14431

10. Costa, M.J., Maciel, L.C., Teixeira, J.A., Vicente, A.A., Cerqueira, M.A. (2018): Use of edible films and coatings in cheese preservation: Opportunities and challenges. *Food Research International* 107, 84-92.
https://doi.org/10.1016/j.foodres.2018.02.013
11. Dhumal, C.V., Ahmed, J., Bandara, N., Sarkar, P. (2019): Improvement of antimicrobial activity of sago starch/guar gum bi-phasic edible films by incorporating carvacrol and citral. *Food Packaging and Shelf Life* 21.
https://doi.org/10.1016/j.fpsl.2019.100380
12. Díaz, O., Ferreiro, T., Rodríguez-Otero, J.L., Cobos, Á. (2019): Characterization of chickpea (*Cicer arietinum* L.) flour films: Effects of pH and plasticizer concentration. *International Journal of Molecular Sciences* 20.
https://doi.org/10.3390/ijms20051246
13. Guidara, M., Yaich, H., Richel, A., Blecker, C., Boufi, S., Attia, H., Garna, H. (2019): Effects of extraction procedures and plasticizer concentration on the optical, thermal, structural and antioxidant properties of novel ulvan films. *International Journal of Biological Macromolecules* 135, 647-658.
https://doi.org/10.1016/J.IJBIOMAC.2019.05.196
14. Hashemi Gahruie, H., Eskandari, M.H., Van der Meeren, P., Hosseini, S.M.H. (2019): Study on hydrophobic modification of basil seed gum-based (BSG) films by octenyl succinate anhydride (OSA). *Carbohydrate Polymers 219*, 155-161.
https://doi.org/10.1016/j.carbpol.2019.05.024
15. Hashemi Gahruie, H., Mostaghimi, M., Ghiasi, F., Tavakoli, S., Naseri, M., Hosseini, S.M. H. (2020): The effects of fatty acids chain length on the techno-functional properties of basil seed gum-based edible films. *International Journal of Biological Macromolecules* 160, 245-251.
https://doi.org/10.1016/j.ijbiomac.2020.05.136
16. Hashemi, S.M.B., Mousavi Khaneghah, A., Ghaderi Ghahfarrokhi, M., Eş, I. (2017): Basil-seed gum containing *Origanum vulgare subsp. viride* essential oil as edible coating for fresh cut apricots. *Postharvest Biology and Technology* 125, 26-34.
https://doi.org/10.1016/j.postharvbio.2016.11.003
17. Heydarian, M., Jooyandeh, H., Nasehi, B., Noshad, M. (2017): Characterization of *Hypericum perforatum* polysaccharides with antioxidant and antimicrobial activities: Optimization based statistical modeling. *International Journal of Biological Macromolecules* 104.
https://doi.org/10.1016/j.ijbiomac.2017.06.049
18. Hosseini-Parvar, S.H., Matia-Merino, L., Golding, M. (2015): Effect of basil seed gum (BSG) on textural, rheological and microstructural properties of model processed cheese. *Food Hydrocolloids 43*, 557-567.
https://doi.org/10.1016/j.foodhyd.2014.07.015
19. Jafarzadeh, S., Salehabadi, A., Mohammadi Nafchi, A., Oladzadabbasabadi, N., Jafari, S. M. (2021): Cheese packaging by edible coatings and biodegradable nanocomposites; improvement in shelf life, physicochemical and sensory properties. *Trends in Food Science and Technology* 116.
https://doi.org/10.1016/j.tifs.2021.07.021
20. Khazaei, N., Esmaiili, M., Emam-Djomeh, Z. (2016): Effect of active edible coatings made by basil seed gum and thymol on oil uptake and oxidation in shrimp during deep-fat frying. *Carbohydrate Polymers* 137, 249-254.
https://doi.org/10.1016/j.carbpol.2015.10.084
21. Kim, S., Baek, S.K., Song, K.B. (2018): Physical and antioxidant properties of alginate films prepared from *Sargassum fulvellum* with black chokeberry extract. *Food Packaging and Shelf Life* 18, 157-163.
https://doi.org/10.1016/J.FPSL.2018.11.008
22. Kim, S.Y., Hyeonbin, O., Lee, P., Kim, Y.S. (2020): The quality characteristics, antioxidant activity, and sensory evaluation of reduced-fat yogurt and nonfat yogurt supplemented with basil seed gum as a fat substitute. *Journal of Dairy Science* 103, 1324-1336.
https://doi.org/10.3168/JDS.2019-17117
23. Korish, M., Abd Elhamid, A.M. (2012): Improving the textural properties of Egyptian kariesh cheese by addition of hydrocolloids. *International Journal of Dairy Technology* 65.
https://doi.org/10.1111/j.1471-0307.2011.00818.x

24. Lima, A.E.F., Andrade, P.L., de Lemos, T.L.G., Uchoa, D.E. de A., Siqueira, M.C.A., do Egito, A.S., Braga, R.C., da Costa, J.N., Teixeira Sá, D.M.A. (2021): Development and application of galactomannan and essential oil-based edible coatings applied to "coalho" cheese. *Journal of Food Processing and Preservation* 45. https://doi.org/10.1111/jfpp.15091
25. Lucera, A., Mastromatteo, M., Conte, A., Zambrini, A.V., Faccia, M., Del Nobile, M.A. (2014): Effect of active coating on microbiological and sensory properties of fresh mozzarella cheese. *Food Packaging and Shelf Life* 1, 25-29. https://doi.org/10.1016/j.fpsl.2013.10.002
26. Mei, J., Yuan, Y., Wu, Y., Li, Y. (2013): Characterization of edible starch–chitosan film and its application in the storage of Mongolian cheese. *International Journal of Biological Macromolecules* 57, 17-21. https://doi.org/10.1016/J.IJBIOMAC.2013.03.003
27. Mirhosseini, H., Amid, B.T. (2013): Corrigendum to A review study on chemical composition and molecular structure of newly plant gum exudates and seed gums. *Food Research International* 46. https://doi.org/10.1016/j.foodres.2013.03.021
28. Mohammad Amini, A., Razavi, S.M.A., Zahedi, Y. (2015): The influence of different plasticisers and fatty acids on functional properties of basil seed gum edible film. *International Journal of Food Science and Technology* 50, 1137-1143. https://doi.org/10.1111/ijfs.12765
29. Moradi, F., Emamifar, A., Ghaderi, N. (2019): Effect of basil seed gum based edible coating enriched with echinacea extract on the postharvest shelf life of fresh strawberries. *Journal of Food Measurement and Characterization* 13, 1852-1863. https://doi.org/10.1007/s11694-019-00104-9
30. Nourozi, F., Sayyari, M. (2020): Enrichment of Aloe vera gel with basil seed mucilage preserve bioactive compounds and postharveçdçöfçst quality of apricot fruits. *Scientia Horticulturae* 262. https://doi.org/10.1016/j.scienta.2019.109041
31. Olawuyi, I.F., Kim, S.R., Lee, W.Y. (2021): Application of plant mucilage polysaccharides and their techno-functional properties' modification for fresh produce preservation. *Carbohydrate Polymers* 272. https://doi.org/10.1016/j.carbpol.2021.118371
32. Oraç, A., Konak Göktepe, Ç., Demirci, T., Akın, N. (2023): Biodegradable edible film based on basil seed gum: The effect of gum and plasticizer concentrations. *Journal of Polymers and the Environment* 31. https://doi.org/10.1007/S10924-023-02923-W
33. Ozdemir, C., Demirci, M. (2006): Selected microbiological properties of kashar cheese samples preserved with potassium sorbate. *International Journal of Food Properties*, 9. https://doi.org/10.1080/10942910600596191
34. Ozturkoglu-Budak, S., Akal, H. C., Bereli, N., Cimen, D., Akgonullu, S. (2021): Use of antimicrobial proteins of donkey milk as preservative agents in Kashar cheese production. *International Dairy Journal*, 120. https://doi.org/10.1016/j.idairyj.2021.105090
35. Pena-Serna, C., Penna, A. L. B., Lopes Filho, J. F. (2016): Zein-based blend coatings: Impact on the quality of a model cheese of short ripening period. *Journal of Food Engineering* 171, 208-213. https://doi.org/10.1016/J.JFOODENG.2015.10.039
36. Polat Yemiş, G., Sezer, E., Sıçramaz, H. (2022): Inhibitory effect of sodium alginate nanoemulsion coating containing myrtle essential oil (*Myrtus communis* L.) on *Listeria monocytogenes* in Kasar cheese. *Molecules* 27. https://doi.org/10.3390/molecules27217298
37. Pourmolaie, H., Khosrowshahi Asl, A., Ahmadi, M., Zomorodi, S., Naghizadeh Raeisi, S. (2018): The effect of Guar and Tragacanth gums as edible coatings in Cheddar cheese during ripening. *Journal of Food Safety* 38. https://doi.org/10.1111/jfs.12529
38. Razavi, S.M.A., Mortazavi, S.A., Matia-Merino, L., Hosseini-Parvar, S.H., Motamedzadegan, A., Khanipour, E. (2009): Optimisation study of gum extraction from Basil seeds (*Ocimum basilicum* L.). *International Journal of Food Science and Technology* 44, 1755-1762. https://doi.org/10.1111/j.1365-2621.2009.01993.x

39. Rençber, F., Önlü, H.,Ferit Atasoy, A. (2024). Assessment of lactic acid bacteria isolated from traditional Muş Tulum cheese. *Mljekarstvo* 74 (4), 296-311. https://doi.org/10.15567/mljekarstvo.2024.0405
40. Sabbah, M., Di Pierro, P., Dell'Olmo, E., Arciello, A., Porta, R. (2019): Improved shelf-life of Nabulsi cheese wrapped with hydrocolloid films. *Food Hydrocolloids* 96, 29-35. https://doi.org/10.1016/J.FOODHYD.2019.05.010
41. Seydim, A. C., Sarikus-Tutal, G., Sogut, E. (2020): Effect of whey protein edible films containing plant essential oils on microbial inactivation of sliced Kasar cheese. *Food Packaging and Shelf Life* 26. https://doi.org/10.1016/j.fpsl.2020.100567
42. Silva, S.P.M., Ribeiro, S.C., Teixeira, J.A., Silva, C.C.G. (2022): Application of an alginate-based edible coating with bacteriocin-producing *Lactococcus* strains in fresh cheese preservation. *LWT* 153. https://doi.org/10.1016/j.lwt.2021.112486
43. Soltani, M., Say, D., Guzeler, N. (2024). Changes in texture profile and mineral content of ultrafiltered white cheese produced using different salt concentrations. *Mljekarstvo* 74 (1), 64-74. https://doi.org/ 10.15567/mljekarstvo.2024.0105
44. Uma Devi, P. (2001): Radioprotective, anticarcinogenic and antioxidant properties of the Indian Holy Basil, *Ocimum sanctum* (Tulasi). *Indian Journal of Experimental Biology* 39, 185-190.
45. Ünalan, I.U., Arcan, I., Korel, F., Yemenicioğlu, A. (2013): Application of active zein-based films with controlled release properties to control *Listeria monocytogenes* growth and lipid oxidation in fresh Kashar cheese. *Innovative Food Science and Emerging Technologies* 20, 208-214. https://doi.org/10.1016/j.ifset.2013.08.004
46. Wang, L., Liu, F., Wang, A., Yu, Z., Xu, Y., Yang, Y. (2017): Purification, characterization and bioactivity determination of a novel polysaccharide from pumpkin (*Cucurbita moschata*) seeds. *Food Hydrocolloids* 66. https://doi.org/10.1016/j.foodhyd.2016.12.003
47. Yangilar, F. (2015): Chitosan/whey protein (CWP) edible films efficiency for controlling mould growth and on microbiological, chemical and sensory properties during storage of göbek kashar cheese. *Korean Journal for Food Science of Animal Resources* 35, 216-224. https://doi.org/10.5851/kosfa.2015.35.2.216
48. Yangilar, F., Oğuzhan Yildiz, P. (2016): Casein/natamycin edible films efficiency for controlling mould growth and on microbiological, chemical and sensory properties during the ripening of Kashar cheese. *Journal of the Science of Food and Agriculture* 96, 2328-2336. https://doi.org/10.1002/jsfa.7348
49. Yilmaz, F., Dagdemir, E. (2012): The effects of beeswax coating on quality of Kashar cheese during ripening. *International Journal of Food Science and Technology* 47, 2582-2589. https://doi.org/10.1111/j.1365-2621.2012.03137.x
50. Zhou, Y., Chen, X., Chen, T., Chen, X. (2022): A review of the antibacterial activity and mechanisms of plant polysaccharides. *Trends in Food Science and Technology* 123. https://doi.org/10.1016/j.tifs.2022.03.020