SİDAS MEDYA
Akademik Gıda®
ISSN Online: 2148-015X
https://dergipark.org.tr/tr/pub/akademik-gida

Akademik Gıda 20(1) (2022) 20-29, DOI: 10.24323/akademik-gida.1097814

Research Paper / Araştırma Makalesi

Effect of Production Method and Temperature on Quality Characteristics of Shalgam Beverages during Storage

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Received (Geliş Tarihi): 11.11.2021, Accepted (Kabul Tarihi): 02.02.2022
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ABSTRACT

Shalgam has been a fermented beverage produced in high amounts and consumed widely in Turkey in recent years. Despite its potential, there is no specific processing method or temperature for the production of shalgam beverages. Therefore, in this study, some changes in shalgam obtained by using two production processes (conventional and rapid processes) at 25 and 35°C were monitored during 4 months of storage. In particular, changes in color values that might affect product quality and attractiveness were influenced by production method, temperature and storage time. The highest a* and b* color values were found in samples produced by using the rapid process at 25°C (5.61 and 0.12, respectively) while the lowest values were found in those manufactured by the conventional method at 35°C. The L* values of beverages changed by storage time. In addition, while the content of anthocyanins decreased by storage time, the content of total antioxidants increased. Additionally, when production temperatures were compared, total aerobic mesophilic bacteria counts in shalgam beverages were higher at 35°C than 25°C. All samples produced at two different temperatures and with two different methods showed a decrease in the number of lactic acid bacteria at the end of storage time. Considering all the changes, it could be concluded that it would be inappropriate to store shalgam beverages at room temperature for 4 months or longer without using any heat treatment or preservative.

Keywords: Shalgam beverages, Storage, Different production methods, Temperature, Quality

Şalgam Suyunun Depolanması Sırasındaki Kalite Özellikleri Üzerine Üretim Yöntemi ve Sıcaklığının Etkisi

ÖZ

Şalgam suyu, son dönemde yüksek üretim ve tüketim potansiyeline sahip fermente bir Türk içeceğidir. Bu potansiyele rağmen şalgam suyunun üretimi için belirli bir sistem ve sıcaklık yoktur. Bu nedenle bu çalışmada, 25 ve 35°C'de iki üretim prosesi (geleneksel ve hızlı prosesler) kullanılarak elde edilen şalgam sularında 4 aylık depolama süresince meydana gelen bazı değişimler tartışılmıştır. Özellikle kalite ve çekiciliği etkileyen renk değerlerindeki değişimler üretim yöntemi, sıcaklık ve depolamadan etkilenmiştir. En yüksek a* ve b* değerleri, hızlı proses kullanılarak 25°C'de (sırasıyla 5.61 ve 0.12) üretilen numunelerde bulunurken, en düşük değerler 35°C'de geleneksel yöntemle elde edilenlerde bulunmuştur. L* değeri depolama ile değişim göstermiştir. Ayrıca depolama ile antosiyanin miktarı azalırken toplam antioksidan miktarı artmıştır. Ek olarak, sıcaklıklar karşılaştırıldığında, şalgam suyu 35°C'de genel olarak daha yüksek toplam aerobik mezofilik bakteri sayısı göstermiştir. İki farklı sıcaklıkta ve iki farklı yöntemle

üretilen tüm numunelerde, depolama sonunda laktik asit bakteri sayısında azalma gözlenmiştir. Tüm değişiklikler göz önüne alındığında, şalgam suyunun herhangi bir ısıl işlem veya koruyucu madde kullanılmadan 4 ay veya daha uzun süre oda koşullarında saklanmasının uygun olmayacağı söylenebilir.

Anahtar Kelimeler: Şalgam suyu, Depolama, Farklı üretim yöntemleri, Sıcaklık, Kalite

INTRODUCTION

Shalgam beverages are turbid fermented drinks with a red/purple color and a sour taste generated by the action of lactic acid bacteria (LAB) and to a lesser extent yeast [1]. It was defined with the regulation made in the standard regarding shalgam beverages Anonymous [2] in 2003. According to this standard, it is produced as follows. To the extract obtained by mixing bulgur flour, sourdough, drinking water and cooking salt, and subjecting it to lactic acid fermentation, with the purple/black carrot and if desired turnip radish is mixed. The mixture is then subjected to lactic acid fermentation. It is a beverage prepared by adding hot pepper powder to the product obtained and making it durable by heat treatment if desired [2]. Besides the protective properties of lactic acid formed as a result of lactic acid fermentation in shalgam beverages [3]; lactic acid has properties that include adding flavor and aroma to shalgam beverages, easing digestion, controlling the pH of the digestive system, and allowing the body to more absorb some minerals [4, 5].

The history of shalgam beverages production is very old, and until today, it is produced and consumed in small quantities in small workshops, under stairs and family-type enterprises or directly for households [4]. Shalgam beverages are produced and consumed intensively in the southern provinces of our country such as Adana and Mersin and the districts of these provinces. In addition, its consumption has spread throughout the country in recent years and even exceeding the borders of the country, it has become a product that is consumed in some European capitals especially where Turkish origin people have a dense population [6, 7]. However, there is no standard technique for the production technique of this fermented beverage, which has become extremely popular. However, shalgam beverages production is commercially made by the conventional process and fast process without fermentation of dough [1].

Various factors affect the completion and duration of fermentation in shalgam beverages production. Although the microflora in the environment and the chemical composition of the raw materials are important parameters affecting the fermentation, the most important parameter is the fermentation temperature [6]. Studies on shalgam beverages production have gained momentum in recent years, but there are still important points to be emphasized. Especially, shalgam beverages have a limited shelf life and changes in shalgam beverages during storage have not been studied much. For this reason, in this present research, some changes in shalgam samples obtained at 25°C and 35°C temperatures by using 2 different methods and storage were emphasized.

MATERIALS and METHODS

In the manufacture of beverages, “black/purple carrot, turnip radish, bulgur flour (setik), bread yeast, rock-salt, and water” were utilized and these ingredients were bought from the local market in Niğde (Turkey).

Shalgam Beverage Production

Shalgam samples were manufactured by two methods which “conventional method” and “fast method” and two different temperatures. Shalgam beverage production by the conventional process was carried out according to Canbaş and Deryaoğlu [4] with some modification. In brief, 3% bulgur flour, 0.2% salt, and 0.2% yeast mixture were added to drinking water and then kneaded until the dough was brought to consistency. The obtained dough was allowed to ferment in 25 liters of plastic drums at 25°C. The first fermentation was carried out for 3 days. The dough was extracted 4 times with water at the end of the process. Liquid from the first fermentation was transferred into a second fermentation tank for main fermentation also known as carrot fermentation. 15% cleaned and chopped black carrots, 1% salt and 1% chopped turnips were added. After this, the fermentation tank was filled with distilled water. The fermentation tank was closed and fermentation was done at 25°C and 35°C (Figure 1). In the fast process, the first fermentation is not carried out. In brief, 3% bulgur flour, 1% chopped turnip radish, 15% chopped black carrot, 1.2% salt, 0.2% press baker’s yeast and water were added to the plastic drums and then fermented in incubators with the temperature set to 25 and 35°C [6] (Figure 2).

All fermentations were followed by measuring titration acidity (TA). The fermentations were terminated when the minimum concentration of TA (6 g/L) needed to be found in the fermented shalgam beverages according to Anonymous [2] was reached. After production, each of the shalgam beverages was left at +4°C for one day. At the end of the time, it was filtered and transferred to bottles. Bottled samples were divided into two parts and the first group was taken to +4°C for zeroth (0^{th}) day analysis, the second part was taken to the fermentation room for the 4^{th}-month analysis and stored at fermentation room for 4 months. Regular minimum and maximum temperature measurements were taken during storage, and storage was carried out at a temperature of 25±3°C. Chemical, sensory analyzes and microbiological counts were made in the manufactured shalgam beverages on the 0^{th} day of storage and 4^{th} month of storage, and the changes that occurred at the end of storage in shalgam beverages were produced at different temperatures and with different methods were examined. Thus, the changes in

shalgam beverages produced by different production methods on the limited shelf life of shalgam beverages, which is the most important problem for shalgam beverages producers today, were focused on.

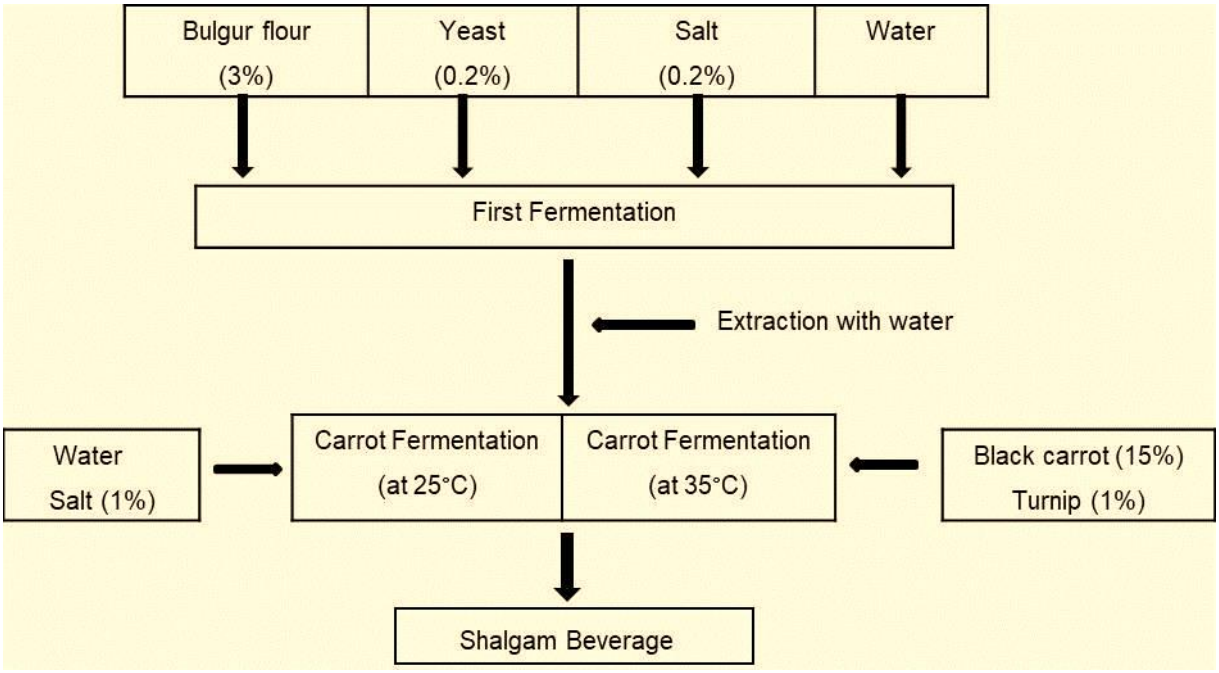

Figure 1. Shalgam beverage production by conventional process

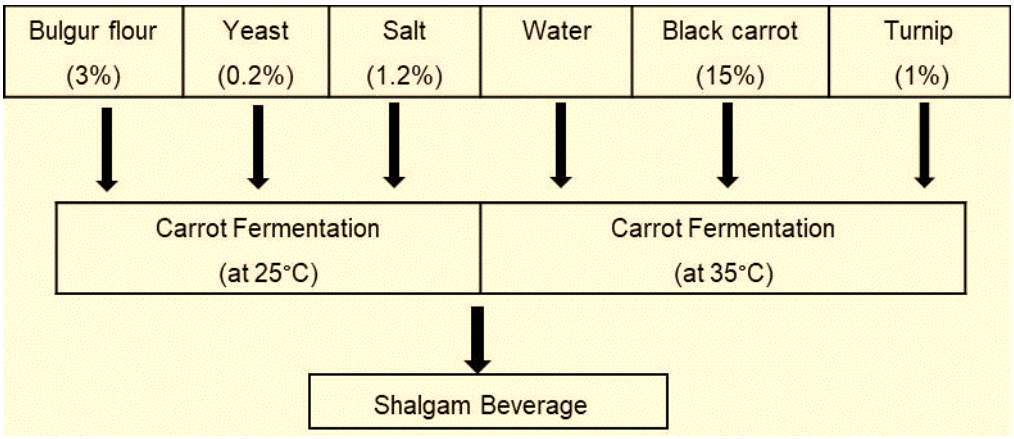

Figure 2. Shalgam beverage production by rapid process

Chemical Analyses

pH was determined directly by using a pH meter (Inolab, Weilheim, Germany). Titratable acidity values were determined by titrating shalgam beverages sample up to pH 8.1 with 0.1 N sodium hydroxide and expressed as g lactic acid/L [6, 8, 9]. The concentration of sugar remaining in shalgams was determined using the phenol-sulfuric acid method [14]. Salt in shalgam beverages was defined by titration with 0.1 N $AgNO_3$ solution [9]. The dry solid and ash were determined according to AOAC [8].

The total anthocyanin amount was analyzed by Spectrophotometric (Shimadzu UV1201, Kyoto, Japan) methods and expressed as cyanidin-3-glycoside at 510 and 700 nm absorbance values [10, 11]. Antioxidant capacity analyses were carried out by DPPH way Klimczak et al. [12] with some modifications. 100 µL of the sample was taken for analysis, 3 mL of DPPH was used. The determined absorbances were measured at 515 nm in a spectrophotometer (Perkin-Elmer, 300 UV/VIS, Massachusetts, USA, 2005). Determined results are given in %.

Color values were determined by direct measurements of absorbances at three different nm (“420 nm, 520 nm and 620 nm”) in the spectrophotometer and calculations made from these measurements. The color intensity (CI) value was obtained by summing all absorbance values (CI = 420 nm + 520 nm + 620 nm). Tint was obtained by dividing the OY420 absorbance value by the OY520 absorbance value [13]. Color composition expressed as %; OY_{420}% is yellow, OY_{520}% is red, OY_{620}% is blue and also dA% is brightness [13]. The color index was determined according to Canbaş and Fenercioğlu [14].

In determining the color values of shalgam beverages samples, the Hunter lab color measuring device was used and results were obtained as international L*, a* and b* systems [15].

Microbiological Analyses

Plate Count Agar (PCA, Merck, 1.05463, Darmstadt, Germany), Potato Dextrose Agar (PDA, Merck, 1.10130, Germany) and de Man, Rogosa and Sharpe Agar (MRS, Merck, 1.0660, AG, Darmstadt, Germany) medium were used for microbiological analysis. After processing with two different methods (start of storage, day 0) and storing for 4 months, microbial analysis as total aerobic mesophilic bacteria (TAMB) count, total yeasts (TM) count and lactic acid bacteria (LAB) count were conducted on shalgam beverages samples. Both conventional process and fast process samples were plated in PCA for TAMB count, MRS agar for LAB count and PDA for TM count. PCA plate was incubated at 30°C for 48 h in aerobic condition [16, 17]. MRS plates were incubated at 30°C for 72 h in anaerobic conditions [18, 19] and PDA plates were incubated at 25°C for 5 days in aerobic conditions.

Sensory Analyses

Sensory analyses were performed with shalgam beverages samples that were produced by a conventional and fast process which were at two different temperatures at 25°C and 35°C. Since there was no suitable sensory analysis evaluations form that shalgam beverage, the sensory analysis form from Altuğ [20] was used. The form was evaluated in the case of color, smell, flavor and taste. Samples were coded by four digits and 7 panelists joined to analyses. Sensory evaluation was ranked on a ten-point scale.

Statistical Analysis

One-way analysis of variance is used to determine the statistical significance of the data (ANOVA). Duncan's test was used to compare means in statistical analysis using the program SPSS 10.0 for Windows.

RESULTS and DISCUSSION

Results of Chemical Analyses

Chemical analysis results of shalgam samples produced with separate temperatures and methods are shown in Tables 1 and 2. pH value by conventional process, was determined as 3.51 for samples produced at 25°C and 3.54 for samples produced at 35°C. Results after storage were determined as 3.46 and 3.50, respectively. According to the results obtained despite a decrease in pH, generally, this change was not found statistically significant ($p \geq 0.05$). According to Anonymous [2] and many research, it was found that the pH value of shalgam beverages without storage is between 3.30 and 3.80 [5, 14, 21-29] so research result for initial pH value was parallel with these studies. With the fast process, it was determined as 3.58 for samples produced at 25°C and 3.50 for samples produced at 35°C. Results after storage were determined as 3.55 and 3.48, respectively. Although there have not been any studies about the storage effect on pH at shalgam beverages, the pH value of shalgam beverages at fourth-month storage was parallel with the Turkish codex.

On day 0 of storage, the total acidity of shalgam beverages was determined as 6.76 and 6.51 g/L for samples produced by the conventional process (for 25°C and 35°C, respectively), while 6.23 and 6.55 g/L for samples produced by the fast process. It can be said that the reason is that in the conventional process, dough fermentation was carried out initially. After 4 months of storage, the values decreased to 4.85 g/L and 4.09 g/L for the conventional process, 3.54 and 4.72 g/L for the fast process (25°C and 35°C, respectively). This is thought to be due to the activity of wild yeasts that can be found in shalgam beverages. As a result, generally, the production method and production temperature were statistically significant on the total acidity of shalgam beverages ($p \leq 0.05$). When the results of the analysis of shalgam beverages were compared at the before storage and fourth months, total acidity values decreased significantly due to storage ($p \leq 0.05$). The results were consistent with the results obtained in other studies [1, 21-23, 25, 26, 28, 29].

According to the findings, storage increased dry matter content slightly, but the difference was not statistically significant ($p \geq 0.05$). Other studies have indicated that the dry matter content of shalgam beverages is about 2%, which is consistent with our findings [1, 14, 21]. In addition, the salt content of shalgam beverages in all samples was found between 9.36 g/L and 11.70 g/L, this result is similar to Tanguler [1] but lower than the salt content reported in other studies [14, 21, 22]. According to Shalgam Beverages Standard [30], salt in shalgam beverages is limited to 20 g/L in terms of dry matter. The amount of salt obtained in the study complies with the limit values specified in the TS Standard. Ash content changes were determined as % and the results were found to be statistically insignificant ($p \geq 0.05$). According to Shalgam Beverages Standard [30], the amount of ash should be below 15 g/L in terms of dry matter [2]. The amount of ash determined in the study is compatible with the values reported by Tanguler [1], while it is lower than the values reported by Anonymous [2], Deryaoğlu [21], Cırak et al. [23] and Utuş [27].

The highest total sugar amount was determined in the experiments conducted both before and after storage at 35°C in shalgams obtained by both production methods. The total amount of sugar before storage was found to be slightly higher in shalgams obtained by the conventional process. However, it is slightly higher with increasing fermentation temperature. According to the results, the production method, production temperature and storage time were found to be statistically significant on the total sugar amount. Deryaoğlu [21] stated that there was no sugar in the shalgam beverages samples. However, Güneş [31] reported that the total sugar amount was between 0.255-0.288 g/L, Utuş [27] found that the total sugar amount was between 0.09-0.2 g/L.

The results obtained were higher than the amount of sugar determined in the previous studies [21, 27, 31]. It can be said that the most important reason for this is the termination of fermentation when the minimum TA (6 g/L) concentration required in fermented shalgam beverages is reached.

Table 1. Chemical analysis results of shalgam beverages before storage

	Conventional Process		Fast Process	
	25°C	35°C	25°C	35°C
pH	3.51±0.05[a]	3.54±0.09[a]	3.58±0.07[a]	3.50±0.02[b]
Total acidity (%)[α]	6.76±0.33[a]	6.51±0.43[a]	6.23±0.12[b]	6.55±0.13[a]
Dry matter (%)	2.06±0.09[a]	1.91±0.02[b]	1.72±0.30[a]	1.97±0.17[a]
Salt (g/L)	9.50±1.03[a]	9.36±0.83[a]	9.65±2.07[a]	9.50±1.86[a]
Ash content (%)	1.26±0.15[a]	1.20±0.05[a]	1.40±0.10[a]	1.31±0.13[a]
Total sugar (g/L)	0.62±0.03[a]	0.65±0.07[a]	0.51±0.01[b]	0.58±0.01[a]
Total anthocyanin (mg/L)	44.04±13.61[a]	38.63±2.13[a]	35.02±5.53[a]	40.51±1.17[a]
Color intensity	1.27±0.31[a]	1.27±0.52[a]	1.25±0.32[a]	0.96±0.18[a]
Color composition				
OY_{420} (%)	31.10±1.59[a]	30.82±2.46[a]	30.56±1.83[a]	29.10±0.71[a]
OY_{520} (%)	56.25±5.03[a]	56.37±6.83[a]	57.01±4.42[a]	60.41±1.10[a]
OY_{620} (%)	12.64±3.44[a]	12.80±4.37[a]	12.41±2.59[a]	10.48±0.39[a]
dA (%)	21.6±15.98[a]	21.35±21.71[a]	24.15±13.65[a]	34.5±2.97[a]
Color tone	0.55±0.08[a]	0.55±0.11[a]	0.53±0.07[a]	0.48±0.02[a]
Color index	70.72±11.00[a]	70.02±20.61[a]	71.12±12.55[a]	58.50±11.81[a]
Antioxidant (mol TE/mL)	43.16±5.89[a]	36.70±1.94[a]	43.37±0.77[a]	42.29±0.65[a]
L*	14.01±0.19[a]	13.56±0.03[b]	14.46±0.76[a]	13.94±0.64[a]
a*	4.91±0.67[a]	3.62±0.22[b]	5.61±1.70[a]	5.55±1.21[a]
b*	-0.85±0.08[a]	-1.05±0.12[b]	0.12±1.10[a]	-0.55±0.34[a]

[α]: as lactic acid, values with different superscripts (a* and b*) indicate statistically significant differences. The effect of temperature is shown in the table statistically. Statistics on the impact of storage and production methods were made, but the data were not shown in the table.

Table 2. Chemical analysis results of shalgam beverages for after storage for 4 months

	Conventional Process		Fast Process	
	25°C	35°C	25°C	35°C
pH	3.46±0.03[a]	3.50±0.08[a]	3.55±0.06[a]	3.48±0.02[a]
Total acidity (%)[α]	4.85±0.19[a]	4.09±1.15[a]	3.54±0.73[b]	4.72±0.19[a]
Dry matter (%)	2.23±0.01[a]	2.38±0.18[a]	2.09±0.26[a]	2.16±0.04[a]
Salt (g/L)	10.67±1.45[a]	10.52±0.82[a]	11.70±0.00[a]	10.67±1.03[a]
Ash content (%)	1.29±0.08[a]	1.13±0.14[a]	1.30±0.11[a]	1.27±0.03[a]
Total sugar (g/L)	0.39±0.00[b]	0.45±0.05[a]	0.33±0.02[b]	0.36±0.01[a]
Total anthocyanin (mg/L)	21.27±0.96[a]	25.63±5.63[a]	20.36±2.01[a]	11.35±0.53[b]
Color intensity	1.25±0.14[a]	1.04±0.14[a]	0.88±0.00[a]	1.06±0.17[a]
Color composition				
OY_{420} (%)	30.81±0.05[a]	30.27±0.54[a]	28.38±0.67[b]	30.29±1.35[a]
OY_{520} (%)	46.02±8.97[a]	55.85±1.12[a]	60.44±0.63[a]	55.05±5.65[a]
OY_{620} (%)	16.14±0.89[a]	13.86±0.58[b]	9.98±1.71[a]	14.65±4.30[a]
dA (%)	11.45±3.32[a]	20.95±3.61[b]	34.55±1.77[a]	17.45±18.74[a]
Color tone	0.58±0.01[a]	0.54±0.02[a]	0.46±0.02[a]	0.55±0.08[a]
Color index	66.47±6.19[a]	58.52±8.87[a]	53.65±0.64[b]	57.87±3.43[a]
Antioxidant (mol TE/mL)	46.20±6.97[a]	50.40±7.14[a]	56.59±0.51[a]	49.09±1.03[b]
L*	15.27±0.26[a]	15.51±0.79[a]	16.89±1.24[a]	14.62±0.11[b]
a*	5.18±2.56[a]	8.28±2.28[a]	13.24±3.68[a]	3.63±1.77[b]
b*	-0.56±0.01[b]	0.93±0.85[a]	2.65±1.21[a]	-0.39±0.50[b]

[α]: as lactic acid, values with different superscripts (a* and b*) indicate statistically significant differences. The effect of temperature is shown in the table statistically. Statistics on the impact of storage and production methods were made, but the data were not shown in the table.

Total anthocyanin amounts in the before storage results were determined between 35 and 44 mg/L, and the highest value was obtained in products obtained by the conventional process. The amount of anthocyanin in shalgam beverages, in terms of cyanidin-3-glycoside, was stated by other studies to be between 88.3-158 mg/L [26, 31, 32, 33]. When the analysis results are compared with other studies, it was observed that the amount of anthocyanin was slightly lower than other research results. The decrease in the total amount of anthocyanin obtained after 4 months of storage of shalgam beverages samples is statistically significant ($p \leq 0.05$). In a study on mulberry wine stored for 1, 3 and 12 months, it was reported that co-pigmented and polymericocyanins in mulberry wine increased, and monomeric anthocyanins decreased from 83.37% to

48.63% [34]. Similarly, Mazza et al. [35] stated that during the storage of bottled wines, anthocyanins were gradually reduced, possibly due to polymerization reactions. In a study on the amount and change of anthocyanin in high-temperature wine grapes, it was reported that the decrease in anthocyanin amount may not only be due to the decrease of anthocyanin biosynthesis but also by many factors such as chemical and enzymatic degradation [36]. Besides, in a study investigating the effect of microbial load in fruits on anthocyanin degradation in natural fruit juices, a correlation was observed between the kinetics of anthocyanin oxidation and microbial growth in acai [37]. As a result, changes in anthocyanin content can be observed in beverages produced from colored fruits and vegetables depending on the chemical, enzymatic and microbial activities.

In shalgam beverages produced by both methods, a decrease in color density values was observed with storage. OY_{420} (%) values before storage were determined between 29.1 and 31.1, and a decrease in OY_{420} (%) values was determined with increasing temperature or storage in the samples produced by both methods. In addition, higher values were determined at both temperatures in conventional processes. While the results obtained are compatible with the shalgam beverages produced using two different temperatures (10-22°C) [38], they are inconsistent with the results reported by Utuş [27]. OY_{520} (%) values expressing the red color were found to be higher in samples produced with the fast process method before and after storage. The highest values were determined as 60.41% (fast process-35°C) before storage and 60.44% (fast process-25°C) after storage. Moreover, while the red color value increased with fermentation temperature in both methods, it generally decreased with storage. The value of OY_{620} (%) represents the blueness and it was determined between 10.48-12.8 (%) before storage and 9.98-16.14 after storage. On the other hand, higher results were obtained in production with the conventional processes. The color tone values were determined between 0.46-0.58, and higher results were obtained before and after storage in the products obtained by the conventional processes. Color index values generally decreased with increasing temperature. It was found between 58.5-71.12 before storage and 53.65 after storage. In addition, the color index values decreased after 4 months of storage. Utuş [27] found that the color intensity value in shalgam beverages production using different sizes of black carrots was 1.43 the highest, while the lowest value was 1.33. Tanguler [1] reported in his study on filtered and unfiltered shalgam beverages samples that the color intensity decreased in unfiltered and filtered control samples stored at 20°C after 6 months of storage. When the color intensity values are compared with the studies performed, at the end of the storage, they showed similarity with Tanguler [1] and showed a decrease in general. Deryaoğlu [21] stated that the color index of shalgam beverages samples varied between 71 and 131. Tanguler [1] found the color index as 96.55 in the unfiltered sample stored at 20°C and 101 in the filtered sample. Canbaş and Fenercioğlu [14] stated in their study on shalgam beverages samples that the color index ranged between 31 and 100. Tanguler [1] and Deryaoğlu [21] recorded higher color index values, while Canbaş and Fenercioğlu [14] reported similar results. The color indices of the shalgam beverages prepared using both methods decreased after 4 months of storage, indicating that the samples had lost color. As a result of the experiments conducted in parallel, differences were observed in the results of color intensity, tint, color composition (OY_{420}%) and dA% value and were determined to be statistically significant ($p \leq 0.05$). Whereas, among the color composition parameters the changes in red (OY_{520}%) and blue (OY_{620}%), and color index results were statistically insignificant ($p \geq 0.05$). Each color intensity, tint, OY_{420} and OY_{620} value was found higher in shalgams obtained by the conventional process. However, a decrease was observed in color intensity, OY_{420}% and color index samples in all trials with storage.

The highest total antioxidant amount in shalgams obtained at 25 and 35°C by both methods was obtained in shalgams obtained at 25°C by fast process (43.37 mol TE/mL) and the lowest (36.7 mol TE/mL) produced by the conventional process at 35°C. Total antioxidants were found to be higher in shalgams obtained by the fast process, and the total antioxidant decreased in both methods with increasing temperature. In addition, it was identified that the total amount of antioxidants increased with storage. Furthermore, storage had a statistically important impact on the total amount of antioxidants ($p \leq 0.05$). Öztan [24] determined the antioxidant value of shalgam beverages before storage as 33.57 Trolox equivalents by DPHH radical capture method. Başer [39] conducted antioxidant capacity analyses on 11 different commercial shalgam beverages before storage using 3 different methods (DPPH, ABTS and FRAP). Antioxidant capacity amounts in shalgam beverages were found as 2.43-4.36 mol TE/mL with the ABTS method, while it was determined between 3.53-5.96 mol TE/mL with DPPH and 2.01-3.61 mol TE/mL with FRAP. Total antioxidant values are in harmony with the values determined by Öztan [24] and Başer [39]. In a study conducted to investigate the relationship between anthocyanins and the antioxidant capacity of mulberry wine stored for 1, 3 and 12 months, it was reported that anthocyanins decreased and antioxidant capacity increased with storage [34].

Determination of the colors of shalgam beverage samples using the international L*, a* and b* system, objective measurements were made on the Hunter brand colorimeter and the results are shown in Tables 1 and 2. L* value is related to lightness and can take different values between 0-100 according to the color measured. The a* value gives the color red measured in the color range, the color measured in the negative color range green. Likewise, the color measured in the b* positive value range gives yellow, while the color measured in the negative value range gives blue [15, 40]. The temperature has an impact on the L*, a*, and b* values, and for the L* value, while the brightness decreased at 35°C in the conventional process, it decreased even more at 25°C in the fast process.

However, the effect of L* value storage is statistically significant (p≤0.05). Bayram et al. [22] produced shalgam beverages using different amounts of carrots and evaluated the L*, a* and b* results before storage. In the study, while the L* (12.68) value of shalgam beverages containing 10% carrot was compatible with our results, a* and b* values differ. For the a* value, it was determined that the redness increased more at 35°C in the conventional process, while the redness value increased at 25°C in the fast process and the redness decreased as a result of storage at 35°C. The effects of storage, temperature and method on a* and b* values are statistically significant (p≤0.05). In a study, it was reported that anthocyanin, which gives its color to shalgam beverages, undergoes acyl/nonacyl change and degradation with the effect of storage and temperature [41]. On the other hand, it may cause a change in color values due to changes in the acidity of microorganisms that are active in the environment during storage.

Results of Microbiological Analyses

The numbers of LAB, TMAB and TM were found in shalgams obtained by two methods at different temperatures and after 4 months of storage, and the values are given in Table 3.

Table 3. Microbiological analysis results of shalgam beverages

Methods	Temperature	TM (log cfu/mL)	LAB (log cfu/mL)	TAMB (log cfu/mL)
Before Storage				
Conventional Process	25°C	5.90	8.40	4.49
	35°C	6.20	7.13	6.30
Fast Process	25°C	7.19	8.29	6.11
	35°C	6.46	7.80	6.37
After Storage				
Conventional Process	25°C	3.49	6.13	6.22
	35°C	3.74	6.37	6.44
Fast Process	25°C	3.73	6.26	4.08
	35°C	3.29	6.59	4.88

While the number of TAMB in samples produced by the conventional process at 25°C was 4.49 log cfu/mL, the same temperature was found to be 6.11 log cfu/mL in the fast process. The results for samples produced at 35°C are 6.30 log cfu/mL and 6.37 log cfu/mL, respectively. Moreover, when temperatures were compared shalgam beverages at 35°C showed generally higher TAMB counts. According to Anonymous [30] the number of TMAB in shalgam beverages ready for consumption should be between $1.0x10^4$-$1.0x10^5$ cfu/mL [2]. In a study conducted by Çankaya [38] TMAB number was found between 7.87 and 8.09 log cfu/mL at the end of fermentation. Moreover, Aydar [42] found the number of TMAB in shalgam beverages between $2.8x10^7$-$2.0x10^7$ cfu/g. The results were higher than Anonymous [2] and lower than Çankaya [38] and Aydar [42]. TAMB count results were found between 6.22 log cfu/mL and 6.44 log cfu/mL in samples produced by the conventional process and stored. The lowest values after storage were found as 4.08 log cfu/mL in samples produced by the fast process. Results are consistent with Tanguler [1], Yener [29] and Çakır [43].

The number of LAB at 25°C was determined as 8.40 log cfu/mL in the samples produced by the conventional process, while it was 8.29 log cfu/mL in the samples produced by the fast process. The results were determined as 7.13 log cfu/mL and 7.80 log cfu/mL, respectively, at 35°C. In some studies, the number of LAB in shalgam beverages obtained by the conventional process was found to be between $2.0x10^7$-$2.4x10^7$ cfu/g [38, 42]. In another study performed using different methods and starter culture, they found the counts of LAB in shalgam beverages between 7.43-7.74 log cfu/mL [44]. The lowest count results were found to be 6.13 log cfu/mL with the storage of samples produced at 25°C by the conventional process. It was determined as 6.59 log cfu/mL in samples produced and stored at 35°C of the fast method with the highest storage result. High temperature caused a slight decrease in LAB numbers. In previous studies, Öztürk [45] found that the LAB result in the analysis results of shalgam beverages ranged from $2.1x10^5$-$9.3x10^7$ cfu/mL. Güneş [31] determined the result of LAB count as 7.60-8.95 log cfu/mL. Tanguler [1] determined the LAB count as 5.68 log cfu/mL. According to the 0-month analysis results, the LAB count was higher than Özturk 2009 [45], it was compatible with Tanguler [1], Güneş [31] and the 4-month storage results were lower than these studies. The number of LABs in all samples produced with two different temperatures and two different methods decreased after storage.

The TM number (0 day of storage) was found to be 5.90 log cfu/mL in the conventional process and 6.20 log cfu/mL, while in the fast process 7.19 log and 6.46 log cfu/mL. No direct reducing or increasing effect of different temperature applications on TM number in shalgam beverages could be determined. When counting results were compared, higher TM results were observed before storage in samples produced by the fast process. According to the 0. day of storage analysis results, TM count was lower than Tanguler [1], Utuş [27], Güneş [31] and Çankaya [38], compatible with Öztürk [45] and lower than these studies in 4-month storage results. After 4 months of storage, the number of TMs decreased. While the lowest value was found in

samples obtained by the fast process at 35°C with 3.29 log cfu/mL, the highest value was obtained in shalgams produced with the conventional process at 35°C with 3.74 log cfu/mL.

Results of Sensory Analyses

Shalgam beverages produced by the conventional and fast process at different temperatures were evaluated on a scale of ten as color, taste and flavor, and taste. The sensory analyses results were shown in Table 4.

The color sensory analysis points among all 4 months stored shalgam beverages samples were in the range of 7.07-8.78 and the highest point owing to shalgam beverages that produced with the fast process at 35°C. For both conventional and fast processes, 35°C had higher color values. Different from color, shalgam beverages that were produced by the fast process at 25°C had the highest value on odor and flavor category. The sensory analyses points among odor and flavor were in the range of 6.21-7.67. Additionally, shalgam beverages produced with the conventional process at 35°C showed the highest value within the flavor analyses while the lowest value at 25°C. The range of taste points was 5.85-8.28. The most desirable example in terms of flavor is the one produced at 35°C in the fast process and then similarly at all samples, the most desirable samples after 4 months of storage were produced by both conventional and fast process at 35°C. Results revealed that shalgam beverages production with both conventional and fast processes can be used without any significant sensorial differences at 35°C. Besides, sensory analysis results according to panelists were not shown a significant difference in processing methods.

Table 4. Sensory analysis of shalgam beverages samples after storage for 4 months

Properties	Conventional Process		Fast Process	
	25°C	35°C	25°C	35°C
Color	8.07	8.5	7.07	8.78
Odor and Taste	6.21	7.5	7.67	7.46
Flavor	5.85	8.28	7.64	7.14

CONCLUSION

In this study, the effect of the storage process on the quality of shalgam beverages produced with different temperatures (25°C and 35°C) and two different methods (conventional and fast processing) was investigated. It was determined that the production method and temperature affect the total acidity, total sugar, a* and b* values. While the difference between the trials was observed in dA% value, color intensity, hue, OY_{420} % and color composition; the changes in pH, ash, salt, color index, OY_{520} % and OY_{620} % are statistically insignificant. With storage in general; there were changes in dry matter, total anthocyanin, L*, total antioxidant amount. The number of TM and LAB decreased with storage in shalgam beverages produced with conventional and fast processing at 2 different temperatures. Considering the results of the sensory analysis obtained, it was determined that the most popular experiment in terms of odor and aroma was the sample of shalgam beverages produced with fast processing at 25°C and stored for 4 months. In the evaluation made in terms of taste, shalgam beverages produced at 35°C by the conventional process were the most appreciated trial. When the results are evaluated, it can be said that it would not be appropriate to store shalgam beverages in room conditions for 4 months or longer without using any heat treatment or preservatives. However, more detailed studies are needed on this subject.

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