

Review

A Traditional Turkish Fermented Non-Alcoholic Beverage, “Shalgam”

Fatma Coskun

Food Engineering Department, Agricultural of Faculty, Namık Kemal University, 59030 Tekirdag, Turkey; fcoskun@nku.edu.tr; Tel.: +90-282-250-21-62; Fax: +90-282-250-99-54

Academic Editor: Antonio Bevilacqua

Received: 21 July 2017; Accepted: 5 September 2017; Published: 9 October 2017

Abstract: Shalgam is a traditional Turkish beverage produced by lactic acid fermentation. Shalgam is also sold in markets in some European cities. In shalgam production, bulgur flour (formed during the crushing process, it is the part that remains under the sieve after breaking the outer shells of boiled dried wheat for processing), salt, water, purple carrot, turnip, and sometimes red beet is used. The traditional method of production can take 10–12 days. Commercial production takes 4–5 days. Shalgam is a probiotic food and a good source of nutrients. It helps regulate the pH of the digestive system. It contains β -carotene, group B vitamins, calcium, potassium, and iron. People also use it as a medicine because of its antiseptic agents. Shalgam consumption should be increased and become worldwide.

Keywords: shalgam; turnip juice; traditional beverages; şalgam; Turkish beverages

1. Introduction

Human beings began to take advantage of fermentation as soon as they began to store food [1]. Fermented herbal products, which are regarded as important nutrients for the future by scientists, are receiving increased interest due to the lactic acid that is formed as a result of fermentation [2]. Since fermentation enhances the taste, flavor, structure, nutritive value, and shelf life of foods, fermentation products are consumed in considerable quantities in daily life in all societies from the least developed countries to the most developed ones [3,4]. Although there are fermented products that are well known around the world, local products take more time to reach the masses [1]. Shalgam (şalgam) is one of these products. It is also called turnip juice, turnip water, shalgam juice, or shalgam water in various scientific sources. Shalgam is a traditional Turkish fermented beverage. Different formulations and two different methods are used for shalgam production. Turnip bulb, purple carrot, salt, sourdough, bulgur, or bulgur flour are used as ingredients. Shalgam includes microorganisms such as *Lb. plantarum* spp. *arabinosus*, *Lb. fermentum*, *Lb. brevis*, and *Saccharomyces cerevisiae*. Shalgam helps to remove toxins from the body, reduce kidney stones, and treat pubertal acne, eczema, abscesses, whitlow, and hematomas. It is a diuretic and cleans the lungs and bronchi. So it is considered a functional food [5,6]. It is mostly consumed with foods such as Turkish kebabs, meatballs, and fish. It can be used as both a vegetable juice and a pickle. Because of the increased interest in functional foods, it has become more popular [7]. Shalgam, which is a red, sour, delicious drink, is produced in the provinces of Icel, Hatay, Kahramanmaraş, Osmaniye, and Adana (the Mediterranean region of Turkey) [8–10]. The reason for this is that the weather conditions of the region are suitable for the fermentation of shalgam and it is compatible with the local dishes and palate. In recent years it has also been consumed in big cities such as Istanbul, Ankara, and Izmir [9], and sold in markets in some European cities. It is mainly made at home or at the home-scale level, but it is also produced commercially on a small scale. Shalgam, which is sold in a glass or plastic bottle or

unpacked in this region, is consumed as much as other drinks [8]. In this study, general information about shalgam, shalgam production technology, chemical composition, and the microbiological and functional properties of shalgam is given.

2. Production of Shalgam

In the production of shalgam, raw materials such as black carrot (purple carrot can also be used) (*Daucus carota*), turnip (*Brassica rapa*) root, bulgur flour (2–3% of the tannin [11], which is formed during the crushing process and is the part that remains in the sieve after breaking the outer shells of boiled dried wheat for processing [12]), yeast, salt, and water are used. In some regions, red beet (*Beta vulgaris* L. spp. *vulgaris*) root is used in addition to these raw materials in the production of shalgam [13]. Bulgur flour, black carrot, salt, dough, and water are the main ingredients of shalgam. Turnip is added if it is preferred. It improves the sensory properties of shalgam. The black carrot anthocyanins give a dark color to the beverage. The lactic acid produced during fermentation causes its sour taste [14,15]. It has also been reported that turnip is not always available and that it is not often used due to the negative effect on the cost [11]. Besides the raw materials, production stages are also known to vary in the direction of sensory preferences [12]. In the formation of the taste, aroma, and texture of shalgam, microorganisms are a major factor. Sources of lactic acid bacteria (LAB) are dough, other ingredients, and the tanks used in the production of shalgam [16]. At the end of shalgam production, lactic acid remains in large quantities. Lactic acid protects shalgam and helps in the formation of taste and aroma. Acetic acid formed by yeasts and heterofermentative lactic acid bacteria provide the major volatile acidity. Forty-four volatile flavor compounds have been identified in shalgam. These include volatile acids, volatile phenols, carbonyl compounds, esters, higher alcohols, norisoprenoids, terpenols, and lactones, and they contribute to the formation of shalgam aroma [17]. The *Saccharomyces* and non-*Saccharomyces* yeasts and molds in shalgam originate from the environment and the raw materials [9]. Yeasts play an important role in the chemical and sensory properties of shalgam [17]. Non-*Saccharomyces* yeasts oxidize sugars to CO₂ and water. At the same time, low amounts of ethanol and secondary metabolites are formed. Yeasts such as *C. inconspicua* may cause the formation of an unpleasant and undesirable taste or odor. This is one of the most important problems encountered in shalgam [18]. The fermentation of the shalgam usually occurs spontaneously with natural microflora activity from vegetables. Starter culture can also be added [19]. Usually sourdough is used as a yeast source [11,12]. The salt in shalgam is added during production to control the growth of microflora other than LAB, which are salt-tolerant and prevent spoilage [20]. Sodium chloride is used as salt, unless otherwise stated. The salt used in the production of shalgam is generally rock salt [11,12].

3. Production of Shalgam by the Traditional Method

The traditional shalgam production takes place in two stages. The first stage is the stage in which the dough fermentation takes place. At this stage the lactic acid bacteria are enriched. In the second step, the main fermentation takes place. Bulgur flour, salt, sourdough, and enough water are mixed. The mixture is then allowed to ferment at room temperature (at 25 °C) [21–23] for 3–5 days. On cold days, warm water must be used for kneading. During the first fermentation, the acid content increases significantly and the pH drops considerably, mainly due to LAB and the significant activities of the yeast in small amounts [3,9,15,21]. At the end of fermentation, cracks form in the dough. Then the dough is extracted and mixed with water 3–5 times for 5–10 min. When the sediment falls to the bottom, the dough mixture is filtered [7]. The extract helps to start the main fermentation [3,9,15,21]. Extracts obtained from the first fermentation are cleaned and chopped; black carrot, salt, and sliced turnip are added if desired; and these ingredients are combined with enough water in the tank for the second fermentation [3,8,9,11]. Traditionally, wooden tanks are used for fermentation. Today, fiberglass, plastic, or stainless steel tanks are used [21]. Fermentation is usually carried out at ambient temperature (10 °C–35 °C) for 3–10 days. (The fermentation time is

about 7 days at 25 °C) [21–23]. During fermentation, colored compounds (anthocyanins) pass into the liquid. The total acidity increases the activity of mainly LAB. At the end of the fermentation, a red, sour beverage is obtained [3,8,21]. Fermented liquid can be flavored with the addition of bitter or sweet pepper powder [24]. Clarification is not performed in shalgam production. At the end of the fermentation, shalgam is filtered, bottled in non-aerated bottles or plastic containers, and put on the market [11,21]. Thereafter, it should be stored in cold conditions [7] (4 °C) until consumption.

4. Direct Shalgam Production

In the direct production method, dough fermentation is not performed [7,21]. Black carrots are selected, sorted, and cut into small pieces. Later, the chopped black carrots, salt, sliced turnips, *S. cerevisiae* or sourdough, and water are mixed in a tank and allowed to ferment for 3–10 days at 10–35 °C (4–5 days at 25 °C) [6]. Following fermentation, the fermented liquid is removed from the tank and put on the market either openly or in non-aerated bottles and plastic containers [21]. There is no standard method for the commercial or traditional production of shalgam. The fermentation of shalgam occurs spontaneously. Generally, 15% (*w/w*) shalgam from a previous production is added to shalgam. Because shalgam fermentation cultures are not commercially available, they are not used in commercial production. They are only used in production under controlled laboratory conditions. The traditional method is used in the production of the majority of the products in the market [20,21]. Different formulations are used for shalgam production. Raw material quantity changes according to the chosen method. According to one of the formulations, for 10 liters of shalgam, the quantities of turnip bulb, purple carrot, salt, sourdough, bulgur or bulgur flour as material are as follows: 200 g (2%), 2 kg (20%), 150 g (1.5%), 150 g (1.5%), and 1 kg (10%), respectively [6]. According to another formulation, 3% of bulgur flour, 0.2% of sour dough, and 0.2% of rock salt and water (enough to produce dough) are mixed and kneaded. After the first (dough) fermentation, extraction is carried out. A second fermentation (carrot or main) starts by adding 10–20% of black carrot (cut into 3–9 cm lengths), 1–2% of rock salt, 1–2% of sliced turnip, and water.

If shalgam is stored at 4 °C in a closed container, its shelf life is 3–4 months. If sterile filtration is applied, its shelf life is six months at 4–20 °C. Its characteristics do not change during this time. Its shelf life can also be extended by the pasteurization method [24]. However, pasteurization adversely affects the sensory characteristics of shalgam. According to Turkish Food Codex Food Additives, benzoic acid or its salts (sodium, potassium, and calcium benzoate) may be used as chemical additive (maximum 200 mg/L). Sorbic acid is not used for this purpose [17,25]. Shalgam should not contain carrot, turnip, or other raw material particles, or any visible foreign matter. It should be homogeneous. However, the yeast sediment may have sunk to the bottom of the shalgam container. When hot shalgam is consumed, the bite of the added hot pepper may be felt. It is not felt when the shalgam is not served hot. According to the permissible concentrations for food in the Turkish Food Codex, the soluble dry matter is at least 2.5% (*m/m*), the titratable acidity (as lactic acid) is at least 6.0 g/L, the pH is 3.3–3.8, the lactic acid content is 4.5–5.5 g/L, the volatile acid (as acetic acid) content is 0.7–1.2 g/L, salt can be at a maximum of 2.0% (*m/m*), ash can be at a maximum of 1.5% (*m/m*), ash that is insoluble in 10% HCL can be at a maximum of 0.1% (*m/m*), artificial coloring agents should not be found, arsenic (As) can be at a maximum of 0.2 mg/kg, copper (Cu) can be at a maximum of 5.0 mg/kg, zinc (Zn) can be at a maximum of 5.0 mg/kg, iron (Fe) can be at a maximum of 15.0 mg/kg, tin (Sn) can be at a maximum of 200 mg/kg, lead (Pb) can be at a maximum of 0.05 mg/kg, and the color should be red–purple in pH 1.0 and grey–green in pH 7.0 [26,27]. According to the maximum and minimum limits permitted by the related Turkish Standard (TS 11149), total mesophilic aerobic bacteria (TMAB) (cfu/mL) and coliform bacteria (MPN/mL) must be 1.0×10^5 (max.) 1100 (max.), respectively [24].

5. Functional Properties of Shalgam

Shalgam is a highly nutritious and microbiologically safe drink. Due to its acidity, the development of pathogens is difficult. Lactic acid is its most important feature. Besides giving shalgam its sour taste,

lactic acid helps to regulate the pH of the digestive system, keeps it from spoiling, and helps the body make better use of some minerals. The calcium, potassium, and iron in shalgam strengthen the bones and teeth. People also use it as a medicine because its antiseptic agents clean the digestive organs and soothe the bowels [1]. Shalgam is also important because of its appetizing properties and its positive effect on the digestive system [11]. So it is considered a functional food [6]. Anthocyanins and lactic acid bacteria from black carrots used in shalgam production cause a reduction in the risk of cancer and cardiovascular diseases [28,29]. At the same time, shalgam is a probiotic food. Shalgam includes probiotic microorganisms such as *Lb. plantarum*, *Lb. paracasei*, *Lb. brevis*, *Lb. fermentum*, *Lb. pentosus*, *Lb. buchneri*, *Lb. helveticus*, *Lb. reuteri*, *S. cerevisiae*, *Lactococcus*, *Pediococcus*, and *Leuconostoc*.

Probiotics benefit people by enriching the intestinal microflora [30]. Probiotics have an antagonistic effect against enteropathogens in the intestines [31]. Probiotics also have benefits such as lowering serum cholesterol, solving constipation, and preventing cancer formation. Although some of the studies are related to breast and bladder cancer, the majority are related to colorectal cancer [7,32]. The varieties of turnips cultivated for human consumption are rich in vitamins A, B, and C, and in minerals such as calcium, magnesium, iron, phosphorus, sulfur, and iodine. They also contain antiseptic substances [13]. Vitamin C affects skin health, and is an antioxidant at the same time. Vitamin C, by supporting the immune system, is effective at improving bone health and increasing iron absorption in the body. Turnip has glucosinolates that fight cancer. They promote detoxification systems in the body and stimulate the body's own natural antioxidant systems [7]. Turnips are rich in potassium content (1.91 g/kg). Potassium is very effective in maintaining cardiovascular health [33,34]. At the same time, potassium is a positive electrolyte in body cells. It allows normal function of the nerves, heart, bones, kidneys, and stomach to continue [35]. Black carrots contain higher amounts of antioxidant vitamins, carotenoids, and phenolics [36]. B-carotene (pro-vitamin A), found in carrots, has been proven to have positive effects on cardiovascular diseases, cataracts, and the immune system [37]. Such diets increase antioxidant consumption [38], including tocopherols, ascorbate, carotenoids, and phenolics. Flavonoids from phenolics are antioxidants in vitro [39,40]. They contain different groups of flavones, like flavonols, isoflavones, flavononones, and catechins. They also contain blue, red, pink, and purple pigments [41,42]. Cyanidin-3-sinapoylxylosylglucosylgalactoside and its related compounds are the major purple pigments in carrots [43]. Other than their coloring properties, anthocyanins have antioxidant and anticancer activities. They have many health benefits, such as reducing the risk of coronary heart disease and improving visual acuity [44,45]. It has been reported that the content of anthocyanin in fresh black carrots can be up to 1750 mg/kg [46]. Since it contains group B vitamins, it calms the nerves and stomach and has a positive effect on liver function [1]. Beet root is good against influenza and liver diseases [47]. Red beet is the source of anthocyanin. Because of the betalaine, which is a color component, red beet and red beet juice have anti-tumor activity. Betalaine reduces the respiration of cancerous cells [48]. Buckenhüskes and Gierschner [49] state that red beet juice obtained by the lactic acid fermentation method has an inhibitory effect on the development of cancerous cells.

6. Studies on Shalgam

In a review of shalgam sold at the market in Adana, Deryaoğlu [8] detected that the pH and total acidity, lactic acid, volatile acid, alcohol, protein, carbon dioxide, dry matter, ash, salt, Fe, K, P, and Ca amounts in the shalgam samples were 3.33–3.67, 66.40–99.10 mg/L, 5.18–8.44 g/L, 0.57–1.16 g/L, 1.32–7.30 g/L, 0.88–1.83 g/L, 0.44–1.41 g/L, 22.90–29.20 g/L, 14.60–20.65 g/L, 13.7–19.7 g/L, 0.9–2.9 mg/L, 300–1000 ml/L, 10.60–22.20 mg/L, and 89–173 mg/L, respectively. Yener [50] analyzed 10 different shalgam samples in Mersin province. According to the conducted analysis, the total dry matter, total acidity, pH, lactic acid, volatile acid, salt, ash, carbon dioxide of the shalgam samples were, on average, 26.90 g/L, 74.70 mg/L, (pH) 3.78, 7.10 g/L, 0.95 g/L, 16.29 g/L, 17.80 g/L, and 0.66 g/L, respectively. Yilmaz-Ersan and Turan [51] determined some elements in shalgam samples belonging to different producers collected by chance from markets in Bursa province in Turkey. The range of Na, K, Ca, Mg, and P were 4.52–6.15 g/L, 0.27–0.72 g/L, 34.02–148.30 mg/L,

30.61–75.38 mg/L, and 8.72–82.96 mg/L, respectively. The concentrations of heavy metals, such as Cd, Ni, Sn, and Pb, found in shalgam were below 1 mg/L in almost all the samples. Shalgam was reported to be a good source of minerals, containing potassium (300–1000 mg/L), phosphorus (10.6–22.2 mg/L), calcium (89–173 mg/L), and iron (0.2–2.9 mg/L) [21]. Sahin [52] reported the presence of copper in the range of 218–234 µg/L. Zinc concentrations of shalgam were in the range of 530–580 µg/L. The Pb and Ni contents of shalgam samples have been reported to be in the range of 57–65 µg/L and 49–242 µg/L, respectively. İyıcınar [53] produced and stored shalgam herself for a study. At the end of two months of storage, the calcium and phosphorus contents in the shalgam were 34.32–92.57 mg/L and 4.38–51.36 mg/L, respectively. The level of magnesium was 20.85–46.576 mg/L. The Mn contents in shalgam were 0–0.40 mg/L; iron values ranged from 0–0.78 mg/L; zinc concentrations were 0.03–0.73 mg/L. İyıcınar did not detect copper in shalgam. At the end of two months of storage, *Lb. plantarum* and *Lb. brevis* counts were between 5×10^3 log cfu/mL and 2.8×10^4 log cfu/mL and at the end of four months of storage were between 4×10^2 log cfu/mL and 1.49×10^4 log cfu/mL.

Kammerer [54] stated that the main soluble fermentable sugars of black carrot are sucrose (1.20–3.31 g/100 g), glucose (1.10–5.60 g/100 g), and fructose (1.00–34.36 g/100 g). Alasalvar et al. [36] also determined that black carrots are rich in sucrose (4.11 g/100 g) and contain glucose (0.69 g/100 g) and fructose (0.58 g/100 g) in smaller quantities. The total sugar concentration in black carrots is reported to be 5.12–6.45 g/100 g on average and is the main source of carbohydrate used in shalgam fermentation [3]. Glucose, fructose, and sucrose in the turnip are present at a rate of 1.41 g/100 g, 1.10 g/100 g, and 0.206 g/100 g, respectively [55]. Shalgam does not contain sugar because all the sugar is used for fermentation.

In one study, 29 different shalgam samples were bought and investigated. Soluble solid contents were found to be 2.5–4% (*m/m*), the total acidity contents expressed as lactic acid was 6.3–12.6 g/L, pH levels were 3.31–4.13, volatile acid contents expressed as acetic acid were 0.528–3 g/L, salt levels were 1.17–2.574% (*m/m*), ash amounts were 1.32–1.97% (*m/m*), amounts of undissolved ash in 10% HCL were 0.0099–0.19861% (*m/m*), and total phenolic compounds were 1219.39–3388.82 mg/kg. Na-benzoate was added to 19 samples (0.01–0.971 g/L) and sorbic acid was added to 6 samples (0.042–0.482 g/L). Synthetic dye was not added into the samples. In all the shalgam samples, the counts of TMAB were found to be between 3.0×10^3 and 8.86×10^6 cfu/mL. In seven samples, mold was found (1.0×10^3 – 3.0×10^3 cfu/mL). The counts of coliform bacteria, *Escherichia coli*, and *Salmonella* were found to be less than 10 cfu/mL or were not found at all [56]. In a study, a total of 26 shalgam samples (3 of them were self-produced by researchers, 14 of them were bought from marketplace and 9 of them were spoiled or about to be spoiled pieces) were analyzed. In the three samples of shalgam of our own making the results for dry matter (%), salt (%), pH, acidity (g/L), TMAB (cfu/mL), yeast and mold (cfu/mL), and LAB (cfu/mL) were, on average, 3.2; 1.6; 3.4; 7.3; 5.9×10^4 ; 3.2×10^4 ; and 3.2×10^6 cfu/mL, respectively. The same parameters in 14 different samples of shalgam bought from the marketplace were 2.0–2.9; 1.1–2.2; 3.3–3.6; 6.1–9.1; 2.8×10^4 – 7.4×10^6 ; 6.2×10^3 – 1.8×10^6 ; and 2.4×10^4 – 8.6×10^7 cfu/mL, respectively. In spoiled or about to be spoiled samples, these parameters were 1.9–3.2; 1.1–1.6; 3.4–6.8; 0.2–8.7; 1.1×10^5 – 8.6×10^8 ; 9.2×10^5 – 2.2×10^8 ; and 1.4×10^6 – 4.9×10^8 cfu/mL, respectively. No coliform bacteria were detected in the samples [57]. Erginkaya and Ünal Turhan [58] isolated and identified LAB and yeast strains of dominant microflora developed during the fermentation of shalgam produced by the traditional method consisting of two stages. The number of LAB and yeast increased during fermentation. The most dominant LAB and yeast during the first and second fermentation stages were *Lb. plantarum* and *S. cerevisiae*, respectively. Moreover, low populations of *Lb. pentosus* and *C. krusei* were present during fermentation. Özler and Kılıç [59] produced shalgam with different combinations of turnip, red beet, black carrot, bread yeast, bulgur flour, sourdough (shalgam produced by the classical method), and starter culture (a mix of *Lb. plantarum* and *Lb. brevis*, 3%). Shalgam samples were pasteurized at 65 °C for 30 min and stored at +4 °C for six months. At the end of storage, pH values varied between 3.34 and 3.37. At the end of storage, the acidity, dry matter, ash, volatile acid, alcohol, and protein values were 0.52–0.893%,

1.69–3.02%, 0.85–2.23%, 0.03–0.07%, 0.05–0.40%, and 0.38–1.82%, respectively. The lowest pH value belonged to the samples produced using turnip + black carrot (obtained by the conventional method) and turnip + black carrot + red beet (produced using starter culture + yeast). The highest acidity value was obtained from turnip + black carrot (obtained by conventional method) and turnip + black carrot + red beet (produced by using starter culture + yeast). The highest dry matter and ash values were determined in samples of turnip + red beet (starter culture + yeast). The highest amount of volatile acid belonged to the samples produced using turnip + black carrot + red beet (starter culture). The highest amount of alcohol belonged to turnip + black carrot (starter culture + yeast) and turnip + red beet (starter culture + yeast) samples. The highest amount of protein was obtained from samples of turnip + red beet (classical method). In the samples using red beet with turnip, color loss occurred after pasteurization. Turnip + black carrot (starter culture), turnip + black carrot + red beet (starter culture + yeast), and turnip + black carrot (starter culture + yeast) samples had the highest color values. The color index ranged from 0.50 to 86.90 and, with increasing color index, the color darkened. The amount of ascorbic acid in the samples was 0.71–3.37 mg/100 g, the amount of crude cellulose was 0.02–0.67%, the amount of reducing sugar was 0.01–0.06%, and the amount of nitrate was 4.44–348.53 mg/L. Yaldirak [60] found that the number of mold and yeast, which was 6.65 log cfu/mL on the first day of fermentation in shalgam fermented at 25 °C, reached 7.87 log cfu/mL on the last day of fermentation. In shalgam fermented at 35 °C, the number of mold and yeast was 6.65 log cfu/mL on the first day of fermentation and 7.17 log cfu/mL on the last day of fermentation. The number of LAB obtained from shalgam fermented at 25 °C was 10.06 log cfu/mL at the beginning and 11.78 log cfu/mL at the end of fermentation. In the shalgam produced by fermentation at 35 °C, the LAB number, which initially was 10.06 log cfu/mL, reached the highest value of 11.14 log cfu/mL at the end of fermentation. According to the results obtained from the analysis of the biogenic amine, the starting amount of tryptamine was 41.14 mg/L. The amount of tryptamine reached 65.22 mg/L in shalgam fermented at 25 °C at the end of fermentation; it reached 66.03 mg/L in shalgam fermented at 35 °C at the end of fermentation. The number of starting TMAB in the shalgam was 10.25 log cfu/mL. The number of TMAB was found to be 10.43 log cfu/mL in shalgam fermented at 25 °C and 9.37 log cfu/mL in the shalgam fermented at 35 °C at the end of fermentation.

Erginkaya and Hammes [5] investigated the microbial flora that developed during fermentation in the traditional shalgam production, and identified LAB species effective at fermentation. These were *Lb. plantarum* spp. *arabinosus*, *Lb. fermentum*, and *Lb. brevis*. Tangüler and Erten [61] examined the growth of lactic acid bacteria during the fermentation in traditional production. The number of lactic acid bacteria increased during the fermentation. *Lb. plantarum* was dominant during the first and second fermentations. *Lb. paracasei* subsp. *paracasei* also has an important place in all fermentations. *Lb. brevis* and *Lb. fermentum* were other lactic acid bacteria determined in fermentations. *Lb. delbrueckii* subsp. *delbrueckii*, *P. pentosaceus*, and *Leu. mesenteroides* subsp. *mesenteroides* were low in number at the beginning the fermentation and died off during the fermentation. Tangüler and Erten [20] determined that fructose, sucrose, glucose, and arabinose were at 0.006–4.0 g/L, 0.01–1.14 g/L, 0.09–1.902 g/L, and 0.134–0.193 g/L, respectively, in shalgam. The counts of lactic acid bacteria, total mesophilic aerobic bacteria, yeast, non-*Saccharomyces* yeast, and coliform bacteria were found on average to be 6.97, 6.72, 5.64, 4.47, and 1.49 log cfu/mL, respectively. Final pH and amount of total acidity as lactic acid were in the range of 3.28–3.48 and 6.54–7.25 g/L, respectively. Lactic acid, acetic acid, and ethanol levels ranged from 2.66 to 4.74 mg/L, from 0.345 to 1.19 mg/L, and from 0.79 to 5.03 g/L, respectively. *Lb. plantarum* was the predominant lactic acid bacteria. *Lb. brevis*, *Lb. fermentum*, and *Lb. delbrueckii* subsp. *delbrueckii* were found in shalgam samples. In the research, shalgam samples were produced using the traditional method and a direct method. Also, *Lb. plantarum*, *Lb. fermentum*, and *Lb. paracasei* subsp. *paracasei* were inoculated to shalgam samples. At the end of fermentation, total acidity as lactic acid, pH, and the counts of lactic acid bacteria, total mesophilic aerobic bacteria, yeasts, and non-*Saccharomyces* yeasts were found to be 6.33–9.22 g/L, 3.42–3.55, 7.43–7.74 log cfu/mL, 7.03–7.46 log cfu/mL, 6.96–7.50 log cfu/mL, and 4.21–5.19 log cfu/mL, respectively. *Lb. plantarum* was

dominant. *Lb. buchneri* was the second most populous after *Lb. plantarum*. According to the sensory evaluation, the sample produced using the traditional method and an added starter culture obtained the highest score. Analysis of the results indicated that the direct method for the production of shalgam is not preferable [16]. In the work carried out by Tanguler and Erten [14], 18 lactic acid bacteria belonging to the genera *Lactobacillus*, *Lactococcus*, *Pediococcus*, and *Leuconostoc* were isolated from shalgam samples. These samples had been produced in the university laboratory and by small- and large-scale producers in industry. These lactic acid bacteria were individually inoculated into pasteurized black carrot juice and samples were fermented for 10 days. The number of *Lb. plantarum* strains was the highest during fermentation (9.40–9.16 log cfu/mL). *Lb. plantarum*^{bx} produced the highest total acidity as lactic acid (22.86 g L⁻¹). *Lb. paracasei* subsp. *paracasei* 2, *Lb. plantarum*^{cx}, *Lb. plantarum*^{ax}, and *Lb. fermentum* followed it (20.45–22 g/L). Only *Lb. delbrueckii* subsp. *delbrueckii* and *Lb. fermentum* grew at 45 °C, but none of the lactic acid bacteria grew with 18% NaCl and at pH 9.6. According to the sensory analysis, the sample obtained by *Lb. plantarum*^{bx} was preferred. *Lb. fermentum* and *Lb. paracasei* subsp. *paracasei* 2 followed it. According to these findings, *Lb. plantarum*^{bx}, *Lb. fermentum*, and *Lb. paracasei* subsp. *paracasei* 2 were suitable for use as starter cultures for the production of shalgam. In a study conducted by Tangüler and Erten [62], the LAB found in an extraction process that was performed after the dough fermentation were isolated and identified. According to their results, among the LAB isolated one was coccus and the others were rod-shaped. The bacterium most often isolated from extracts was *Lb. plantarum*, followed by *Lb. paracasei* subs. *paracasei* and *Lb. brevis*. The coccus-shaped isolate was *P. pentosaceus*. In a study, the microbial population of shalgam was identified using the 16S rRNA-PCR method. Sequencing results showed that the predominant species were *Lactobacillus* species, including *Lb. casei* ATCC 334, *Lb. casei*, *Lb. casei* subsp. *casei*, *Lb. plantarum* ATCC 14917, *Lb. plantarum* subsp. *plantarum* ST-III chromosome, *Lb. plantarum* JDM1, *Lb. plantarum* subsp., *Lb. plantarum* subsp. *argentoratensis*, *Lb. acidophilus*, *Lb. brevis* ATCC 367, *Lb. brevis*, *Lb. helveticus*, *Lb. helveticus* DSM 20075, *Lb. helveticus* DPC 4571, *Lb. paracasei* subsp. *paracasei*, *Lb. paracasei* subsp. *tolerans*, *Lb. parabrevis*, *Lb. reuteri*, *Lb. delbrueckii* subsp. *lactis*, *Lb. delbrueckii* subsp. *delbrueckii*, *Lb. delbrueckii* subsp. *indicus*, *Lb. gasseri*, and *Lb. sharpeae*. According to these results, shalgam might be a potential source of beneficial LAB [63].

Utuş [64] researched the effect of black carrot size on the quality of shalgam. Shalgam was produced by the traditional method. The black carrots chosen were 2–3 cm in diameter and 10–12 cm length. Black carrots were cut into 3 cm, 6 cm, or 9 cm pieces and were cut into two in length. The highest number (7.64 log cfu/mL) of total bacteria was in sample with black carrot cut in 3cm size; the lowest number (7.08 log cfu/mL) was in sample with black carrot cut in 9 cm size at the end of the fermentation. An increase in the number of lactic acid bacteria was observed in all of the shalgam samples until the 2nd day of the fermentation. The highest number (8.75 log cfu/mL) the 2nd day of the fermentation was in sample with black carrot cut in 3 and 6 cm size. The decrease in the number of lactic acid bacteria continued until the 7th day. The lowest number (7.25 log cfu/mL) was in sample with black carrot sample cut into two in length. These numbers at the end of the fermentation (10th day) were 7.48 log cfu/mL, 7.49 log cfu/mL ve 7.46 log cfu/mL, respectively. The number of *Saccharomyces* spp. yeast was the highest (7.29 log cfu/mL) in sample with black carrot cut in 3cm size, and the lowest (6.32 log cfu/mL) in sample with black carrot sample cut into two in length at the beginning of fermentation. An increase in the number of *Saccharomyces* spp. yeast was observed until the 3rd day of the fermentation. Then the number of *Saccharomyces* spp. yeast decreased until the end of fermentation. At the end of the fermentation, the highest number (7.59 log cfu/mL) of *Saccharomyces* spp. yeast was in sample with black carrot cut in 6 cm size and the lowest number (7.13 log cfu/mL) of *Saccharomyces* spp. yeast was in sample with black carrot sample cut into two in length. The highest number (5.54 log cfu/mL) of non-*Saccharomyces* spp. yeast was in sample with black carrot cut in 3 cm size, the lowest number (4.48 log cfu/mL) was in sample with black carrot cut in 6 cm size at the beginning of fermentation. An increase in the number of non-*Saccharomyces* spp. yeast was observed until the 2nd day of the fermentation. The number (4.82 log cfu/mL) of non-*Saccharomyces* spp. yeast decreased in sample with black carrot cut in 3 cm

size until the 4th day of the fermentation. In other samples, the number of non-*Saccharomyces* spp. yeast continued to increase until the end of fermentation. At the end of the fermentation, the highest number (6.46 log cfu/mL) of non-*Saccharomyces* spp. yeast was in sample with black carrot cut in 9 cm size. Coliform bacteria were at a maximum on the first day but had disappeared by the end of fermentation.

In the study carried out by Ekinçi et al. [29], the total carbohydrate, soluble solid, salt, ash content pH, and total acidity as lactic acid of the commercially shalgam sample were 0.29 g/L, 3.4% w/v, 2.0% w/v, 1.86% w/v, 3.43, and 6.38 g/L, respectively. These values were in accordance with standards. Lactic, acetic, succinic, and citric acid were 8.90, 1.29, 0.22, and 1.25 g/L, respectively. The contents of fructose and sucrose were 0.104 g/L and 0.041 g/L, respectively. The total phenolic content (517.21 µg GAE/mL) and antioxidant capacity (in µmol Trolox equivalents/mL) were determined by 2,2'-azino-bis-(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) (3.42), 1,1-diphenyl-2-picrylhydrazyl (DPPH) (4.44) and ferric reducing/antioxidants power (FRAP) (2.26) assays of the commercial shalgam. These values were similar to those of other common fruit juices. Cyanidin-3-arabinoside, cyanidin-3-glucoside, and cyanidin-3-galactoside were 0.039, 0.21, and 233 ng/mL, respectively. Lactic acid bacteria (specifically *Lactobacillus* spp.) were 4.09 log cfu/mL. The number of total mesophilic aerobic bacteria was 2.89 log cfu/mL. *Lb. plantarum* subsp. *plantarum*, *Lb. casei*, *Lb. brevis*, and *Lb. helveticus* (21 *Lactobacillus* species and subspecies) were detected in the shalgam. It can be deduced that these species are resistant to the acidic conditions created during the fermentation. *Lb. gasseri*, *Lb. acidophilus*, *Lb. delbrueckii* subsp. *lactis*, *Lb. delbrueckii* subsp. *delbrueckii*, and *Lb. delbrueckii* subsp. *indicus* were identified at the beginning of the fermentation but died out later. Shalgam inhibited the growth of Caco-2 cells lines. This was significantly higher inhibition at 3200 µg/mL compared to black carrot. According to these results, shalgam has antioxidant, probiotic, and cell-proliferation-inhibiting properties in addition to the effects of its polyphenolic compounds. Güneş [4] determined that the addition of various quantities of black carrot had effects on the composition of shalgam. In a study where the turnip was produced by the traditional production method, 10%, 12.5%, 15%, 17.5%, or 20% black carrot were added at the beginning of carrot fermentation. The results showed that the total acidity, dry matter, ash, anthocyanins, phenolic compounds, and color index increased as the amount of black carrot increased. The total acidity as lactic acid in 10%, 12.5%, 15%, 17.5%, and 20% black carrot samples was determined to be 4.95 g/L, 5.46 g/L, 6.05 g/L, 6.74 g/L, and 7.45 g/L, respectively. The total number of yeasts varied from 7.15 to 7.80 log cfu/mL at the beginning of the fermentation. The highest yeast content was detected in the sample containing 10% carrots: 7.66 log cfu/mL at the end of the fermentation. The lowest yeast content was obtained in a sample containing 12.5% carrots: 6.76 log cfu/mL. The number of LAB varied between 7.82 log cfu/mL and 7.95/mL in shalgam at the beginning of fermentation. At the end of fermentation the number of LAB varied between 8.95 log cfu/mL (with 20% carrot) and 7.60 log cfu/mL (with 15% carrot). The level of coliform bacteria gradually declined during the fermentation and no coliform bacteria was isolated at the end. The result of sensory evaluation showed that the 17.5% carrot added sample was preferred.

In one study, the aroma compounds in shalgam produced by traditional and direct methods, and addition of lactic acid bacteria cultures were examined. The aroma compounds of shalgam were extracted were extracted by liquid-liquid extraction technique with pentane/dichloromethane and analyzed by gas chromatography-mass spectrometry (GC-MS). In shalgam 20 terpenes, 9 esters, 5 lactones, 9 alcohols, 5 volatile acids, 6 volatile phenols, 3 naphthalenes, 2 carbonyl compounds and 1 C13-norisoprenoids were identified. The total volatile content of the shalgam samples increased with addition of *Lb. plantarum* [65].

In one study conducted by Tangüler et al. [66], the effect of black carrot size on the quality of shalgam was researched. For this purpose, traditional production method was used for shalgam production. The method was performed by cutting the black carrots in 3, 6 and 9 cm pieces and also cutting them lengthwise. Dough fermentation was done for three days and carrot fermentation for nine days. According to the results obtained from the ready-to-serve shalgam samples, total acidity as

lactic acid was 7.15 to 7.75 mg/L, lactic acid was 5.6 to 6.3 mg/L, pH was 3.45 to 3.53, anthocyanin as cyanidin-3-glycoside was between 120.18 and 145.6 mg/L, and total phenolic compounds as OD₂₈₀ were between 23.3 and 28.99. Sensory analysis showed that the preferred sample was the one obtained using 3 cm pieces of black carrot. The results stated that a smaller size of black carrot favorably affected the anthocyanin content, phenolic composition, and sensory properties of shalgam. Özdestand and Üren [67] determined the color values of 20 shalgam samples collected from the markets. The L*, a*, and b* values of shalgam samples were between (0.47) and (5.44), (2.15) and (9.28), and (−0.84) and (1.87), respectively. The L*, a*, and b* values of all samples were, on average, 1.613, 4.589, and 0.951, respectively. In one study, the phenolic and antioxidant contents of shalgam samples from different manufacturers in Adana were analyzed. Most of the compounds detected were hydroxycinnamic acids and their derivatives. Among them, chlorogenic acid was the major hydroxycinnamic acid, followed by p-coumaric, caffeic, and ferulic acids and quercetin glycoside. Additionally, cyanidin 3-xylosyl (glucosyl) galactosides acylated with sinapic acid, ferulic acid, and coumaric acid were detected as major anthocyanins. The antioxidant activity of shalgam was measured using DPPH (2,2-diphenyl-1-picrylhydrazyl) assay. There are strong correlations between antioxidant capacity and total phenolic content of shalgam [68]. In a study conducted by Erçelebi and Özkanlı [69], the pH of two commercial and one homemade shalgam samples were measured at 20 °C and ranged from 3.16 to 3.29. Shalgam juice is a lactic acid fermented beverage and, therefore, the total acidity of shalgam juices was expressed as lactic g/L; it was observed that the total acidity of samples was greater than 8.0 g/L. The total phenolic matter was expressed as gallic acid (mg/mL) and ranged from 642.33 to 783.71. Total monomeric anthocyanin was expressed in terms of cyanidin-3-glycoside (mg/L) and found to range from 41.89 to 83.19. It was found that in home-made shalgam there was a higher amount of anthocyanin when compared with other shalgam samples. TMAB counts ranged from 2.72 to 5.35 log cfu/mL; LAB counts ranged from 2.86 to 5.56 log cfu/mL. Color indices of shalgam samples were (L) 1.63–0.41, (a) 7.02–1.76, and (b) 2.02–0.38. The low color values are the values of the homemade samples. Turker et al. [70] found that total anthocyanin content (as cyanide-3-glucoside equivalents) was between 67.5 and 168.2 mg/L in commercial and laboratory-scale produced samples. This range may be due to the complex interaction between microflora and (poly) phenols during fermentation [71]. In a study, different amounts (10%, 15%, or 20%) of black carrot were used in shalgam production. The effects of these black carrot amounts on chemical properties, total phenolic content, total anthocyanin content, color composition, and sensorial properties of the shalgam were investigated. According to the results, as the amount of black carrots increased, the total phenolic and anthocyanin contents and total acidity increased. When production was complete, the total phenolic contents of shalgam with 10%, 15%, and 20% black carrot were 455.51, 654.01, and 858.51 mg (gallic acid equivalent)/L, respectively. The total anthocyanin content of the samples increased as time went on. At the end of fermentation, in shalgam samples with 10%, 15%, and 20% black carrot, the total anthocyanin contents were 157.52, 214.94, and 306.40 mg cy-3-glu/L, respectively. As a result of sensory evaluation, the shalgam sample with 20% black carrot was the favorite [72]. Toktaş [73] produced shalgam in the laboratory by the direct method and took shalgam samples that were kept for a month after they were produced from three different local markets in Istanbul for comparison purposes. Analysis was performed on the samples collected on the 1st, 12th, and 24th days of fermentation, with three different commercial shalgam beverages, black carrot, and bulgur extracts. The pH of the shalgam beverage sample continuously decreased during lactic acid fermentation. As the fermentation progressed, the total flavonoid content, total phenolic content, anthocyanin compounds, and total antioxidant capacity rose quickly for the first 12 days; those compounds continued to increase towards the end of fermentation, but they were at a lower rate compared with the first 12 days of fermentation. In vitro bioaccessibility tests demonstrate that as the samples pass from the mouth to the intestines, the percentage of bioaccessibility was decreased. For instance, at the end of mouth digestion, the recovery percentages of black carrot in commercial shalgam samples collected on the first 12th and 24th days varied between 43.9 and 56.0% and were statistically identical for flavonoid content.

As the sample passes through the stomach and reaches the intestines, the recovery percentage of samples declined, ranging between 6.7% and 13.9%. Similar results were obtained in terms of phenolic content, anthocyanin compounds, and total antioxidant capacity. Sixteen different phenolics were detected from initial shalgam beverage samples, namely 3,4-dihydroxybenzoic acid, 4-hydroxybenzoic acid, caffeine, catechin, chlorogenic acid, elagic acid, epicatechin, ethyl-3-4-dihydroxybenzoate, ferulic acid, fumaric acid, gallic acid, p-coumaric acid, quercetin, sinapic acid, syringic acid, and vanillin. After performing bioaccessibility tests, no phenolic was detected from the shalgam sample collected on the first day of fermentation. On the other hand, five different phenolics, namely 3-4-dihydroxybenzoic acid, p-coumaric acid, chlorogenic acid, 4-dihydroxybenzoic acid, and epicatechin, were detected from a shalgam sample collected on the 12th and 24th days of fermentation and commercial shalgam samples. As to anthocyanins, only cyanidin was detected, except for in mouth and intestine samples from the first day of fermentation.

In one study, the biogenic amine contents of 20 peppered and non-peppered shalgam samples produced by different manufacturers in Turkey were analyzed. Total biogenic amine contents were between 26.7 and 134.3 mg/L. These values were below the maximum limit allowed. In shalgam samples, cadaverine, putrescine, tyramine, and histamine, were detected. Putrescine was the most commonly found (5.0–42.3 mg/L), followed by tyramine (3.8–41.0 mg/L). The pH, acidity, and total dry matter values of shalgam samples were in the range of 3.15 to 4.25, 0.530% to 1.028% (*w/v*), and 2.33% to 3.67% (*w/w*), respectively. Total free amino acid contents were in the range of 0.0074% to 0.0318% (*w/v*) [74].

7. Conclusions

Shalgam is a traditional Turkish beverage produced by lactic acid fermentation. It is commercially produced as well as traditionally produced in homes. Shalgam is a functional and probiotic food that has been proven to be good for human health. The short shelf life causes some problems related to consumption, however. Many researchers have been working on shalgam to extend the shelf life. Shalgam is best known in Turkey, but deserves to be spread around the world.

Conflicts of Interest: The author declares no conflicts of interest.

References

1. Yardımcı, H.; Özfer Özçelik, A.; Özçelik, F.A. Special Drink: Turnip juice and its effects on health. In Proceedings of the 3rd International Symposium on “Traditional Foods from Adriatic to Caucasus”, Sarajevo, Bosnia and Herzegovina, 1–4 October 2015; p. 577.
2. Buckenhüskes, H.J. Selection criteria for lactic acid bacteria to be used as starter cultures for various food commodities. *FEMS Microbiol. Rev.* **1993**, *12*, 253–272. [[CrossRef](#)]
3. Canbaş, A.; Deryaoğlu, A. A research on the production technique and composition of shalgam juice. *Doga* **1993**, *17*, 119–129. (In Turkish)
4. Güneş, G. A Study Determination of the Most Suitable Quantity of Black Carrot (*Daucus Carota*) for the Production of Shalgam (Salgam). Master’s Thesis, Cukurova University, Adana, Turkey, 2008. (In Turkish)
5. Erginkaya, Z.; Hammes, W.P. A research on the identification of isolated lactic acid bacteria and on the developing microorganisms during the fermentation of shalgam juice. *Gıda* **1992**, *17*, 311–314. (In Turkish)
6. Erginkaya, Z.; Aksan, E. Adana province traditional beverage: Shalgam. In Proceedings of the Traditional Foods Symposium, Van, Turkey, 23–24 September 2004. (In Turkish)
7. İncedayı, B.; Uylaşer, V.; Çopur, U.A. A Traditional Turkish beverage shalgam: Manufacturing technique and nutritional value. *J. Food Agric. Environ.* **2008**, *6*, 31–34.
8. Deryaoğlu, A. A Research on the Processing Techniques and Characteristics of Shalgam Beverage. Master’s Thesis, Cukurova University, Fen Bilimleri Enstitüsü, Adana, Turkey, 1990. (In Turkish)
9. Tangüler, H. Identification of Predominant Lactic Acid Bacteria Isolated from Shalgam Beverage and Improvement of Its Production Technique. Ph.D. Thesis, Cukurova University, Adana, Turkey, 2010. (In Turkish)

10. Altay, F.; Karbancıoğlu-Güler, F.; Başkaya-Dikmen, C.; Heperkan, D. A review on traditional Turkish fermented non-alcoholic beverages: Microbiota, fermentation process and quality characteristics. *Int. J. Food Microbiol.* **2013**, *167*, 44–56. [CrossRef] [PubMed]
11. Canbaş, A.; Fenercioğlu, H.A. Research on shalgam juice. *Gıda* **1984**, *95*, 279–286. (In Turkish)
12. Öztürk, O. A Research on the Composition of Shalgam Beverages Obtained from Adana Area. Master's Thesis, Cukurova University, Adana, Turkey, 2009. (In Turkish)
13. Özler, N. Researches on the Production of Fermented Turnip Juices. Master's Thesis, Uludag University, Bursa, Turkey, 1995. (In Turkish)
14. Tangüler, H.; Erten, H. Selection of potential autochthonous starter cultures from shalgam, a traditional Turkish lactic acid-fermented beverage. *Turk. J. Agric. For.* **2013**, *37*, 212–220. [CrossRef]
15. Canbaş, A. A research on black carrot color material. *Doga* **1985**, *9*, 394–398. (In Turkish)
16. Tangüler, H.; Saris, P.E.J.; Erten, H. Microbial, chemical and sensory properties of shalgams made using different production methods. *J. Sci. Food Agric.* **2015**, *95*, 1008–1015. [CrossRef] [PubMed]
17. Erten, H.; Tangüler, H. Shalgam (Şalgam). In *Handbook of Plant Based Fermented Foods and Beverages*, 2nd ed.; Hui, Y.H., Evranuz, Ö.E., Eds.; CRC Press Taylor & Francis Group: Boca Raton, FL, USA, 2012; pp. 657–664.
18. Karaoglan, A. Inactivation of Yeasts Which Causes Spoilage of Shalgam Beverage by Using Pulsed UV Light. Master's Thesis, Cumhuriyet University, Sivas, Turkey, 2013. (In Turkish)
19. Demir, N.; Bahçeci, K.S.; Acar, J. The effects of different initial *Lactobacillus plantarum* concentrations on some properties of fermented carrot juice. *J. Food Process. Preserv.* **2006**, *30*, 352–363. [CrossRef]
20. Tanguler, H.; Erten, H. Chemical and microbiological characteristics of shalgam (salgam): A traditional Turkish lactic acid fermented beverage. *J. Food Qual.* **2012**, *35*, 298–306. [CrossRef]
21. Erten, H.; Tanguler, H.; Canbas, A. A traditional Turkish lactic acid fermented beverage: Shalgam (salgam). *Food Rev. Int.* **2008**, *24*, 352–359. [CrossRef]
22. Arıcı, M. Microbiological and chemical properties of drink called Shalgam (Mikrobiologiste und chemische eigenschaften von Salgam). *Ernahrungs Umsch.* **2004**, *51*, 10.
23. Vogelmann, S.A.; Seitter, M.; Singer, U.; Brandt, M.J.; Christian, H.C. Adaptability of lactic acid bacteria and yeasts to sourdoughs prepared from cereals, pseudocereals and cassava and use of competitive strains as starters. *Int. J. Food Microbiol.* **2009**, *130*, 205–212. [CrossRef] [PubMed]
24. Anonymous. *TS 11149 Standard of Turnip Juice*; Turkish Standards Institute: Ankara, Turkey, 2003. (In Turkish)
25. Anonymous. *Turkish Food Codex Regulation on Food Additives*; Published Official Newspaper Date: 30.06.2013, Official Newspaper Number: 28693; Republic of Turkey Ministry of Food, Agriculture and Livestock: Ankara, Turkey, 2013. (In Turkish). Available online: <http://www.resmigazete.gov.tr/eskiler/2013/06/20130630-4.htm> (accessed on 10 April 2017).
26. Anonymous. *Turkish Food Codex Communiqué on the Maximum Levels of Certain Contaminants in Foodstuffs*. No. 2008/22. 2008. (In Turkish). Available online: <http://www.resmigazete.gov.tr/eskiler/2008/05/20080522-7.htm> (accessed on 10 April 2017).
27. Artık, N.; Poyrazoğlu, E.S. Traditional food and traditional food legislation. In *Proceedings of the 1st International Symposium "Traditional Foods from Adriatic to Caucasus"*, Tekirdag, Turkey, 15–17 April 2010; p. 1. (In Turkish)
28. Gobetti, M.; Di Cagno, R.; De Angelis, M. Functional microorganisms for functional food quality. *Crit. Rev. Food Sci. Nutr.* **2010**, *50*, 716–727. [CrossRef] [PubMed]
29. Ekinçi, F.Y.; Baser, G.M.; Özcan, E.; Üstündağ, Ö.G.; Korachi, M.; Sofu, A.; Blumberg, J.B.; Oliver Chen, C.Y. Characterization of chemical, biological, and antiproliferative properties of fermented black carrot juice, shalgam. *Eur. Food Res. Technol.* **2016**, *242*, 1355–1368. [CrossRef]
30. Michida, H.; Tamalampudi, S.; Pandiella, S.S.; Webb, C.; Fukuda, H.; Kondo, A. Effect of cereal extracts and cereal fiber on viability of *Lactobacillus plantarum* under gastrointestinal tract conditions. *Biochem. Eng. J.* **2006**, *28*, 73–78. [CrossRef]
31. Tamer, C.E.; Karaman, B.; Aydoğan, N.; Çopur, Ö.U. Some traditional fermented foods and effects on health. In *Proceedings of the Traditional Foods Symposium*, Van, Turkey, 23–24 September 2004. (In Turkish)
32. Salminen, S.; Bouley, C.; Boutron-Ruault, M.C. Functional food science and gastrointestinal physiology and function. *Br. J. Nutr.* **1998**, *80*, 147–171. [CrossRef]
33. Khaw, K.T.; Barrett-Connor, E. Dietary potassium and stroke-associated mortality. *N. Engl. J. Med.* **1987**, *316*, 235–240. [CrossRef] [PubMed]

34. McCarron, D.A.; Reusser, M.E. Are low intakes of calcium and potassium important causes of cardiovascular disease? *Am. J. Hypertens.* **2001**, *14*, 206–212. [[CrossRef](#)]
35. Akhter, P.; Ashraf, N.; Mohammad, D.; Orfi, S.D.; Ahmad, N. Nutritional and radiological impact of dietary potassium on the Pakistani population. *Food Chem. Toxicol.* **2003**, *41*, 531–534. [[CrossRef](#)]
36. Alasalvar, C.; Grigor, J.M.; Zhang, D.; Quantick, P.C.; Shahidi, F. Comparison of volatiles, phenolics, sugars, antioxidant vitamins, and sensory quality of different colored carrot varieties. *J. Agric. Food Chem.* **2001**, *49*, 1410–1416. [[CrossRef](#)] [[PubMed](#)]
37. Velioglu, S. Effects of natural antioxidants on human health. *Gida.* **2000**, *25*, 167–176. (In Turkish)
38. Ames, B.N.; Shigenaga, M.K.; Hagen, T.M. Oxidants, antioxidants, and the degenerative diseases of aging. *Proc. Natl. Acad. Sci. USA* **1993**, *90*, 7915–7922. [[CrossRef](#)] [[PubMed](#)]
39. Rice-Evans, C.A.; Miller, N.J.; Paganga, G. Structure antioxidant activity relationships of flavonoids and phenolic acids. *Free Radic. Biol. Med.* **1995**, *20*, 933–956. [[CrossRef](#)]
40. Wang, H.; Cao, G.; Prior, R.L. Oxygen radical absorbing capacity of anthocyanins. *J. Agric. Food Chem.* **1997**, *45*, 304–309. [[CrossRef](#)]
41. Mazza, G.; Miniati, E. *Anthocyanins in Fruits, Vegetables and Grains*; CRC Press: Boca Raton, FL, USA, 1993; p. 362.
42. Shahidi, F.; Naczk, M. *Phenolics in Food and Nutraceuticals*; CRC Press: Boca Raton, FL, USA, 2004; p. 576.
43. Glassgen, W.E.; Wray, V.; Strack, D.; Metzger, J.W.; Seitz, H.V. Anthocyanins from cell suspension cultures of *Daucus carota*. *Phytochemistry* **1992**, *31*, 1593–1601. [[CrossRef](#)]
44. Timberlake, C.F.; Henry, B.S. Anthocyanins as natural food colorants. *Prog. Clin. Biol. Res.* **1988**, *280*, 107–121. [[PubMed](#)]
45. Kobaek-Larsen, M.; Christensen, L.P.; Vach, W.; Ritskes-Hoitinga, J.; Brandt, K. Inhibitory effects of feeding with carrots or (–)-falcarinol on development of azoxymethane-induced preneoplastic lesions in the rat colon. *J. Agric. Food Chem.* **2005**, *53*, 1823–1827. [[CrossRef](#)] [[PubMed](#)]
46. Kırca, A.; Özkan, M.; Cemeroğlu, B. Stability of black carrot anthocyanins in various fruit juices and nectars. *Food Chem.* **2005**, *97*, 598–605. [[CrossRef](#)]
47. Günay, A. *Special Vegetable Gardening: Leek, Onion, Garlic, Asparagus, Raveat, Spinach, Beet, Chard*, 2nd ed.; Ankara University: Ankara, Turkey, 1992; p. 278. (In Turkish)
48. Rasic, J.; Bogdanovic, L.J.G.; Kerenji, A. Gemüsesäfte antikanserogene eigenschaften von milchsauer vergorenem rote-bete-saft. *Flüssiges Obst* **1984**, *1*, 25–28.
49. Buckenhüskes, H.; Gierschner, K. Charakterisierung von laktofermentierten gemüsesäften aus dem Handel. *Flüssiges Obst* **1990**, *57*, 78–81.
50. Yener, D. A Research on the Physical, Chemical, Sensory and Microbiological Properties of Shalgam Taken from Different Sales Places in Mersin Province Center. Master's Thesis, Trakya University, Tekirdag, Turkey, 1997. (In Turkish)
51. Yılmaz-Ersan, L.; Turan, M.A. Major and minor element concentrations in fermented shalgam beverage. *Int. J. Food Prop.* **2012**, *15*, 903–911. [[CrossRef](#)]
52. Sahin, I. Determination of Heavy Metals in Turnip Juice by Voltammetry and ICP-AES Methods. Master's Thesis, Balikesir University, Balikesir, Turkey, 2001. (In Turkish)
53. İyiçınar, H. The Effect of Different Formulations on Turnip Juice Production in Controlled Conditions. Master's Thesis, Selcuk University, Konya, Turkey, 2007. (In Turkish)
54. Kammerer, D.; Carle, R.; Schieber, A. Quantification of anthocyanins in black carrot extracts (*Daucus carota* ssp. *sativus* var. *atrorubens* Alef.) and evaluation of their color properties. *Eur. Food Res. Tech.* **2004**, *219*, 479–486. [[CrossRef](#)]
55. Rodriguez-Sevilla, M.D.; Villanueva-Suárez, M.J.; Redondo-Cuenca, A. Effects of processing conditions on soluble sugars content of carrot, beetroot and turnip. *Food Chem.* **1999**, *66*, 81–85. [[CrossRef](#)]
56. Çakır, P.; Dağlıoğlu, F.; Gök Barut, S.; Apaydın, D. A research on the composition of shalgam beverages produced in Turkey and their conformity to food legislation. In Proceedings of the 2nd International Symposium on Traditional Foods from Adriatic to Caucasus, Struga, Macedonia, 24–26 October 2013; p. 458.
57. Özer, N.; Çoksöyler, F.N. Some chemical and microbiological properties of salgam juice. *Gida* **2015**, *40*, 31–38. [[CrossRef](#)]
58. Erginkaya, Z.; Ünal Turhan, E. Enumeration and identification of dominant microflora during the fermentation of shalgam. *Acad. Food J.* **2016**, *14*, 92–97.

59. Özler, N.; Kılıç, O. Researchs on the production of fermented turnip juices. *Gıda* **1996**, *21*, 323–330. (In Turkish)
60. Yaldirak, G. Effects of Different Fermentation Temperature on the Formation of Biogenic Amines in Shalgam Produced by Natural Fermentation. Master's Thesis, Sakarya University, Sakarya, Turkey, 2011. (In Turkish)
61. Tanguler, H.; Erten, H. Occurrence and growth of lactic acid bacteria species during the fermentation of shalgam (salgam), a traditional Turkish fermented beverage. *Food Sci. Technol.* **2012**, *46*, 36–41. [[CrossRef](#)]
62. Tangüler, H.; Erten, H. Identification of lactic acid bacteria isolated from extract obtained during shalgam beverage Production. In Proceedings of the 3rd Traditional Foods Symposium, Konya, Turkey, 10–12 May 2012; pp. 56–58. (In Turkish)
63. Başer, G.M.; Sofu, A.; Özcan, E.; Korachi, M.; Ekinci, F.Y. Characterization of dominant microbial populations in shalgam juice using 16S rRNA. *New Biotechnol.* **2012**, *29*, S118. [[CrossRef](#)]
64. Utus, D. The Effect of Black Carrot (*Daucus Carota*) Size Usage on the Quality of Shalgam Production. Master's Thesis, Cukurova University, Adana, Turkey, 2008. (In Turkish)
65. Tangüler, H.; Selli, S.; Sen, K.; Cabaroglu, T.; Erten, H. Aroma composition of shalgam: a traditional Turkish lactic acid fermented beverage. *J. Food Sci. Technol.* **2017**, *54*, 2011–2019. [[CrossRef](#)]
66. Tangüler, H.; Utus, D.; Erten, H. Effect of black carrot size usage on the quality of shalgam (Şalgam) a traditional Turkish lactic acid fermented beverage. *Indian J. Tradit. Knowl.* **2014**, *13*, 647–653.
67. Özdestand, Ö.; Üren, A. Determination of the color values (L*, a*, b*) of some turnip juice samples sold in the market. In Proceedings of the 2nd Traditional Foods Symposium, Van, Turkey, 27–29 May 2009; pp. 613–615. (In Turkish)
68. Kelebek, H. Phenolic composition and antioxidant properties of shalgam: Traditional beverage from southern Turkey's cities. In Proceedings of the 2nd International Symposium on Traditional Foods from Adriatic to Caucasus, Struga, Macedonia, 24–26 October 2013; p. 551.
69. Ercelebi, E.A.; Özkanli, O. A traditional fermented beverage: Shalgam juice. In Proceedings of the 1st International Symposium on Traditional Foods from Adriatic to Caucasus, Tekirdag, Turkey, 15–17 April 2010; pp. 1019–1020. (In Turkish)
70. Turker, N.; Aksay, S.; Istanbulu, O.; Artuvan, E. A study on the relation between anthocyanin content and product quality: Shalgam as a model beverage. *J. Food Qual.* **2007**, *30*, 953–969. [[CrossRef](#)]
71. Rodríguez, H.; Curiel, J.A.; Landete, J.M.; de las Rivas, B.; de Felipe, F.L.; Gómez-Cordovés, C.; Mancheño, J.M.; Muñoz, R. Food phenolics and lactic acid bacteria. *Int. J. Food Microbiol.* **2009**, *132*, 79–90. [[CrossRef](#)] [[PubMed](#)]
72. Bayram, M.; Erdoğan, S.; Esin, Y.; Saraçoğlu, O.; Kaya, C. Effect of black carrot quantity on composition and sensorial properties of turnip Juice, Shalgam. *Acad. Food J.* **2014**, *12*, 29–34. (In Turkish)
73. Toktaş, B. Effect of Fermentation on Phenolic Content, Anthocyanin Stability, Antioxidant Capacity and In Vitro Bioaccessibility during Shalgam (Şalgam) Beverage Production. Master's Thesis, Istanbul Technical University, Istanbul, Turkey, 2016.
74. Özdestand, Ö.; Üren, A. Biogenic amine content of shalgam (Şalgam): A traditional lactic acid fermented Turkish beverage. *J. Agric. Food Chem.* **2010**, *58*, 2602–2608. [[CrossRef](#)] [[PubMed](#)]

