REPUBLIC OF TURKEY
YILDIZ TECHNICAL UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

OPTIMIZATION OF ULTRAVIOLET PASTEURIZATION CONDITIONS OF SHALGAM (ŞALGAM) JUICE AND DETERMINATION OF ITS SHELF LIFE

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MSc. THESIS
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A thesis submitted by Kübra Doğan in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** is approved by the committee on 18.12.2017 in Department of Food Engineering, Food Engineering Program.

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December, 2017

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LIST OF SYMBOLS

b*	Blueness-yellowness
°C	Celsius
%	Percentage
a*	Redness-greenness
±	Standard deviation
ΔE	Total Color difference
L*	Whiteness-blackness

LIST OF ABBREVIATIONS

DPPH	2,2-diphenyl-1-pcyrylhydrazyl
$AlCl_3$	Aluminum Trichloride
C	Chroma
cfu	Colony forming unit
FCR	Folin- Ciocalteu reagent
f	Frequency
GAE	Gallic acid equivalent (mg L^{-1})
g	Gram
Hz	Hertz
HCl	Hydrochloric acid
kHz	Kilo Hertz
LAB	Lactic acid bacteria
L	Liter
Log	Logarithm
mg	Milligram
mL	Milliliter
min	Minute
nm	Nanometer
NTU	Nephelometric turbidity unit
K_2CrO_4	Potassium chromate
P	Power (W)
pH	Power of Hydrogen
$AgNO_3$	Silver nitrate
NaOH	Sodium hydrochloride
spp	Subspecies
TS	Thermosonication
TMAB	Total mesophilic aerobic bacteria
TPC	Total phenolic content
TEAC	Trolox equivalent antioxidant capacity measurement
US	Ultrasound
UI	Ultrasound intensity
UV	Ultraviolet
UV-A	Ultraviolet (315-400 nm)
UV-B	Ultraviolet (280-315 nm)
UV-C	Ultraviolet (200-280 nm)
V	Volume

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ABSTRACT

OPTIMIZATION OF ULTRAVIOLET PASTEURIZATION CONDITIONS OF SHALGAM (ŞALGAM) JUICE AND DETERMINATION OF ITS SHELF LIFE

Kübra DOĞAN

Department of Food Engineering
MSc. Thesis

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In recent years, production of fermented and probiotic vegetable juices has gained importance in around the world with the increasing demand of consumers for healthier foods. Several preservatives are used and heat treatment is performed to commercial shalgam juice after fermentation in order to increase its shelf life. The purpose of this study was to investigate the effect of continuous system ultraviolet (UV) treatment as an alternative non-thermal food preservation method on quality characteristics of shalgam juice with the aim of eliminating the disadvantages of thermal treatment and preservative use in shalgam juice. For this aim, fermented shalgam juice samples were treated to 5 UV processing conditions comprising from 3 different flow rates (1500-2500-3500 ml / min), 2 different temperatures (5-25 ˚C) and 2 different UV intensities (5.1-10.1 mW / cm^2). Then the samples were analyzed for their microbiological, physicochemical, bioactive and sensorial characteristics during storage for 5 months at 4 °C. In the results, UV treatment gave comparable and favorable results in terms of microbiological and bioactive properties of the shalgam juices with heat treatment while UV treated samples got higher ($P<0.05$) sensorial scores than the heat treated one.

About 3 logs higher inactivation in TMAB counts were observed in UV treated samples than the control. In conclusion, UV treatment exhibited better product quality properties and was approved as an alternative non-thermal preservation method instead of conventional heat treatment process to be used in shalgam juice production.

Keywords: Ultraviolet (UV), fermentation, shalgam, shelf life, non-thermal food preservation methods

ÖZET

ŞALGAM SUYUNUN ULTRAVİYOLE PASTÖRİZASYON KOŞULLARININ OPTİMİZASYONU VE RAF ÖMRÜNÜN BELİRLENMESİ

Kübra DOĞAN

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Son yıllarda tüm dünyada fermente ve probiyotik sebze suları üretimi, tüketicilerin sağlıklı gıdalara olan talebinin artmasıyla önem kazanmıştır. Ticari şalgam suyuna, raf ömrünü artırabilmek amacıyla fermentasyondan sonra çeşitli koruyucular kullanılmakta ve ısıl işlem uygulanmaktadır. Bu çalışmanın amacı, şalgam suyunda ısıl işlem ve koruyucu kullanımın dezavantajlarının giderilmesi hedefiyle modern gıda muhafaza yöntemlerinden, ısıl olmayan etki mekanizmalarına sahip ultraviyole teknolojisinin sürekli sistemde şalgam suyunun kalite özelliklerine etkisinin araştırılmasıdır. Bu amaçla fermente şalgam suyu örneklerine 3 farklı akış hızı (1500-2500-3500 ml/dk), 2 farklı sıcaklık (5-25 ˚C) ve 2 farklı ultraviolet şiddeti (5,1-10,1 mW/cm^2) kullanılarak 5 işlem koşulu uygulanmıştır. Daha sonra örnekler 5 ay boyunca 4 ˚C de depolama boyunca mikrobiyal, fizikokimyasal, biyoaktif ve duyusal karakteristikleri bakımından analiz edilmiştir. Sonuç olarak, UV uygulanan örnekler ısıl işlem uygulanana göre daha yüksek duyusal skorlar alırken UV uygulaması şalgam suyunun mikrobiyolojik ve biyoaktif özellikleri bakımından ısıl işlemle kıyaslanabilir ve olumlu sonuçlar vermiştir. UV uygulanan örneklerin TMAB sayılarında kontrole göre yaklaşık 3 log daha fazla inaktivasyon gözlenmiştir. Sonuç olarak, UV uygulaması, daha iyi ürün kalite

özellikleri vermiş ve şalgam suyu üretiminde kullanılmak üzere konvensiyonel ısıl işlem prosesi yerine alternatif bir ısıl olmayan muhafaza yöntemi olarak onaylanmıştır.

Anahtar Kelimeler: Ultraviyole, fermantasyon, şalgam, raf ömrü, ısıl olmayan gıda muhafaza yöntemleri

CHAPTER 1

INTRODUCTION

1.1 Literature Review

In modern food production methods, various processing technologies are used in order to provide and maintain an acceptable food quality during shelf life. Fermentation is known as one of the oldest technologies that has been used for food preservation. Fermentation is defined as the formation of new metabolic products such as alcohols and acids as a result of breakdown of macromolecules such as carbohydrates by microorganisms. During fermentation process, undesired microorganisms are inhibited by the fermenting microbes on the food source. Preservation of food by fermentation dates back ancient times. The cheese was produced with the domestication of animals in the years 6.000 B.C. while the Sumerians and Egyptians produced wine and beer in the years 2.000-4.000 B.C. Despite the fact that fermented food production is a very old method, the association of microorganisms with fermentation has been understood with the discovery of pasteurization by Louis Pasteur in 1861 [1].

The preservation of fruits and vegetables through fermentation dates back to 1.000-1.500 B.C. With the fermentation of plant-based foods in all over the world, a great quantity and variety of products have been produced. Many vegetables such as cucumbers, cabbages, carrots, celeries, shalgams, radishes, beets and peppers have been fermented [2]. Also in Turkey, pickle production through lactic acid fermentation has been performed. Microorganisms play the major role in obtaining fermented foodstuffs. Interest in lactic acid bacteria has increased ever since the relation between bacteria with food fermentation was understood [3].

Traditional food production and preservation methods and consumption routines, which have emerged through thousands of years of human experience, are methods that have been developed and accepted with the needs of local people. Among these methods, fermentation and drying are the most commonly used as the oldest methods. Fermentation, which is one of the methods used in the preservation of many foods for centuries, still maintains its popularity in food industry [4].

Fermentation increases the taste, flavor, structure, stability and shelf life of the food, it is possible to find various fermented products in all societies with different levels of development. Apart from universal fermented foods such as various pickles, vinegar, cheeses and alcoholic beverages, production and consumption of traditional fermented products such as shalgam juice, kefir and boza have been limited in different regions of the World. Shalgam juice production is widespread in Mersin, Hatay, Osmaniye, Kahramanmaraş and especially Adana [4]. Production of shalgam juice has become widespread throughout the country over the last 20-30 years. There are 163 enterprises legally producing 215 different brands of shalgam juice in Turkey [5].

In a study conducted by Kusznierewicz, the juice of white cabbage left for fermentation was extracted with methanol (day 0, day 4, day 7, day 11 and day 14), freeze-dried and its total antioxidant capacity was examined (with the DPPH method). Total antioxidant capacity of cabbage juice on day 0 was 0.26 μmol TE / mL, whereas at day 14 it reached the value of 2.31 μmol TE / mL. In the freeze-dried cabbage extract on day 0 it was 2.31 μmol TE / mL, whereas it reached to 4.20 [6].

In a study conducted by Limón, 3 different fermentations were carried out on cranberry beans. The first was natural fermentation; the second was performed with addition of *Bacillus subtilis* as starter culture to the cranberry beans, sterilized for 15 minutes at 121°C and freeze-dried (solid extract); the third was conducted by adding *Lactobacillus plantarum* bacteria, and kept at 37°C for fermentation (liquid extract). For the duration of 0-96 hours of fermentation of the solid-state cranberry beans, the pH value varied between 6.30-7.09, the number of bacteria was between 5.73-8.21 log cfu/g, and the amount of phenolic matter between 15.89-35.93 mg / g. For the duration of 0-96 hours of natural fermentation of cranberry beans, the pH value varied between 6.57-4.29, the number of bacteria between 1.01-8.77 log cfu/g, and the amount of phenolic matter was between 20.68-20.16 mg/g. For the duration of 0-96 hours of fermentation of liquid

state cranberry beans, the pH value varied between 6.63-3.72, the number of bacteria was between 7.04-5.92 log cfu/g, and the amount of phenolic content was between 20.68-17.79 mg / g [7].

Shalgam juice is low acid food that is offered directly for consumption. Lactic acid, in addition to giving a sour taste to shalgam juice, also provides features such as digestion facilitation, refreshing feeling, regulating the pH of the digestive system and enabling the body to benefit more from certain minerals. Lactic acid fermentation products obtained at acidic pH levels are regarded as reliable products in terms of health because pathogenic microorganisms cannot develop within them [8, 9].

In a study conducted by Canbaş and Deryaoğlu, the composition of shalgam juices that were obtained from the market were examined and shalgam juice production trials were carried out. As a result of the production trials, it was revealed that the first fermentation period lasted 3-5 days while the second fermentation period lasted 5-6 days. In the analyses conducted on shalgam juice samples, the following values ranges were identified; total acid 66.9-99.1 me/L, lactic acid 5.18-8,44 g/L, volatile acid 0.57-1.16 g/L, alcohol 1.32-7.30 g/L, pH 3.33-3.67, protein 0.88-1.83 g/L, iron 0.9-2.9 mg/L, potassium 300-1,000 mg/L, phosphorus 10.6-22.2 mg/L, and calcium 89-173 mg/L. It was stated that quantities of bulgur flour, black carrot, salt and water used in the production of shalgam juice were effective in the mineral content found in shalgam juice [10].

In a study conducted by Özhan and Çoksöyler, shalgam juice storage was performed in 4 different temperature (5, 20, 30, 35 °C) and 4 different pH levels (3.0, 3.5, 4.0, 4.5), and the inactivation of e. coli was traced by using first degree of reaction kinetics. As a result of the study, it was stated that no statistically significant inactivation was observed in the number of Escherichia coli at 5°C with pH 4.5, 4, 3.5 and at 20°C with pH 4.5, 3.5, 4. In the same study, it was stated that the D value increased with increasing pH and that the D value decreased with increasing temperature. As a result, it was reported that no risk would arise from storing shalgam juices with pH < 4 in room temperature conditions. Other than that, it was determined that the pH value was 3.34-3.64, the amount of salt was 17.5 g/L, and that the total acidity was 0.648 (in terms of % lactic acid) [11].

In Turkish Standards, shalgam juice is defined as; "A product that is obtained by mixing bulgur flour, sourdough, potable water (TS 266) and edible salt (TS 933), subjecting the mixture to lactic acid fermentation, adding şalgam (*Brassica rapa*), purple carrot (*Daucus carota*), and powdered hot pepper (TS 241) to the obtained extract, subjecting the new mixture once again to lactic acid fermentation, which can be made long-lasting with heat treatment if desired" (anonymous, 2003). Although it is written that the shalgam juice can be made long-lasting with heat treatment in the definition; due to the changes in taste resulting from heat treatment, this method has almost never found application in shalgam juice production.

In a study conducted by Erginkaya and Hammes, sourdough was obtained spontaneously, and shalgam juice was produced with this sourdough. The identification of lactic acid bacteria that was effective in fermentation was done by examining the microbiologic flora for the duration of the fermentation. In this study, they have isolated *Lactobacillus plantarum spp. arabinoses, Lactobacillus fermentum* and *Lactobacillus brevis* from the shalgam juice [12].

Shalgam juice, as mentioned above, cannot be subjected to heat treatment due to the negative changes that occur in its taste. One of the most important problems encountered in the industrial production of shalgam juice is that the product has a fairly limited life. Although it is allowed in the shalgam juice standard to subject shalgam juice to heat treatment in order to make it longer-lasting, this is not preferred due to the negative changes regarding its taste [5] and the life of the shalgam juice is limited to the formation of disruptive flora, as no protective precautions are undertaken. In this case, the easy shalgam juice production technique must be developed and standardized so as to extend its shelf life. Making the shalgam juice that is obtained through fermentation become long-lasting is commercially very important. Studies conducted in this regard are insufficient [4].

As the negative effects of heat treatment on the sensory quality characteristics of shalgam juice are known, heat treatment applications are not preferred in shalgam juice production technologies. Therefore, traditional methods are used even in high-capacity productions, and conducting a standard production is difficult. Although important studies have been conducted regarding the identification of the characteristics of

shalgam juice, no detailed study regarding the application of non-heat based methods for the preservation of shalgam juice was encountered.

Due to the increase in consumer demands for high quality food products, among the developed non-heat food processing technologies, there are applications such as high hydrostatic pressure (HHP), pulsed the electric field (PEF), ultraviolet radiation (UV), ultrasonication and ozone [13, 14]. As these new food storage techniques are generally implemented at lower temperature levels in comparison to traditional processing methods, losses in food quality are minimal.

Walkling-Ribeiro et al. identified that the pH and Brix values of apple juice changed very little with UV application on apple water (at 20°C for 30 minutes), whereas the ascorbic acid content was reduced from 5.4 mg/100 ml to 4.0 mg/100 ml [4].

Uysal Pala and Kırca Toklucu determined that the pH, titration acidity, Brix and total phenol content of orange juice showed no significant change after being subjected to a UV application using a 9-lamp UV reactor, whereas the ascorbic acid content was reduced by 10.6% as a result of 4 transitions from the system [16].

In a study by Tran and Farid, it was determined that UV application (73.8 mJ/cm2) on freshly squeezed orange juice prolonged the shelf life by 5 days, but that increasing the applied UV dose (1008 mJ/cm2) resulted in the same level of ascorbic acid deterioration (17%) with that of heat treatment. No significant change in the pH value of orange juice was observed with the UV application. On the other hand, it was identified that the UV application, contrary to heat treatment, was successful in inactivating the pectin methylesterase enzyme [17].

Noci et al. applied UV, pulsed electric field (PEF) and UV-PEF combinations as an alternative to heat treatment in apple juice, and examined the effects of these applications on certain quality characteristics (color, pH, Brix, non-enzymatic Browning index) as well as antioxidant capacity, polyphenol oxidase (PPO) and peroxidase activity of fresh apple juice. When compared with heat treatment, it has been determined that the total phenol content of apple juices is less affected by UV and PEF applications and that PPO and POD activity is unaffected by UV application [18].

In a study, conducted by Guerrero-Beltran and Barbosa-Canovas, the effects of UV application on the PPO activity of manga nectar (pH of 3.8, 13.0 ° Brix) were examined and the highest PPO reduction was observed after the shortest UV application time (5 min). After 30 min on a 0.45 L/min flow UV application, the remaining PPO activity was determined to be approximately 19%. Researchers particularly emphasized the possibility that UV beams could be absorbed by organic molecules, which might trigger the photoinactivation of enzymes such as PPO. Indeed, the UV energy was absorbed by conjugated double bonds, later forming single bonds by reacting with O_2. As a result, UV application can alter molecules containing conjugated double bonds or lead to chemical changes [19].

Guerrero-Beltran et al. found that an increase in the UV application duration led to an increase in the total color difference (ΔE) of grape, cranberry and grapefruit juices [20]. On the other hand, Keyser et al. determined that the UV application had no important effect on the unique flavors of fruit juices [21].

In a study conducted by Gouma et al., the resistance to UV-C (200-280 nm) process of yeasts that frequently cause deterioration in fruit juices (*Saccharomyces cerevisiae, S. bayanus, Zygosaccharomyces bailii, Dekkera anomala* and *D. bruxellensis*) was investigated. It was observed that Saccharomyces strains were resistant to UV applications and that yeast inactivation decreased with decreasing medium absorptivity. A combined use of UV process with heat treatment (45 – 60 °C) provided higher lethal effect on the yeasts present in fruit juices than the UV process. It was determined that the combined use of UV and heat treatment processes (52.5 and 57.5°C) was more effective in the inactivation of S. cerevisiae when compared to the individual use of each process (Synergistic effect). With the modeling of inactivation data, it was determined that the combined use of UV-C and heat treatment process in order to reduce the S. cerevisiae in clear fruit juice by 5 log required less UV dosage and shorter process duration when compared to the separate use of each process. Industrially, this research showed that the combined use of UV-C and heat treatment process increased the inactivation of deteriorative yeasts in fruit juice. This combined application, despite synergistically increasing the yeast inactivation, was less effective in comparison to the bacteria inactivation. The combined use of UV-C (200-280 nm) with moderate level heat treatment process, by ensuring inactivation of pathogen bacteria and reduced

concentration levels of deteriorative microorganisms like yeast, may be an alternative to pasteurization in the obtaining of a safe and stable product [22].

In a study conducted by Müller et al., the effect of UV-B (280-315 nm) and UV-C (200-280 nm) applications on the shelf life and polyphenol oxidase (PFO) activity of apple and grape juices were investigated. In UV-C applied samples, 2-log cfu/mL microbial inactivation was achieved in the total aerobic microorganisms' load at a dose of 100.47 kJ/L, and as a result, the shelf life was increased. Browning was prevented in the samples preserved in the refrigerator by success in PPO inactivation. However, no changes in the PPO activity and product shelf life were observed in the samples that were subjected to UV-B. As a result of this study, it was concluded that the PPO inactivation of browning reactions in fruit juices could be minimized with UV-C and that shelf life could be extended [23].

1.2 Objective of the Thesis

Shalgam juice, which is one of our traditional drinks that is manufactured with lactic acid fermentation, is commonly known and consumed throughout Turkey, especially in the Çukurova region. Production and exportation of shalgam juice has immensely increased in recent years. Today, industrial shalgam juice production has several problems which need to be solved. The most important issues related to shalgam juice production are the difficulties of starter culture usage, production in batch systems and need to the use of several preservatives in order to increase product shelf life. In addition, sediments present at the bottom of the bottles of shalgam juice negatively affect the visual quality and consumer preference of the product, therefore clear / transparent shalgam juice is preferred. In this study, ultraviolet (UV) technology was tested for non-thermal pasteurization of shalgam juice instead of heat treatment and its effects on product quality parameters during the shelf life were investigated.

1.3 Hypothesis

UV technology can be applied to shalgam juice as a continuous pasteurization system. Therefore it is hypothesized that UV treatment can be used as an alternative non-thermal preservation method to heat based pasteurization that is applied as a batch system in shalgam juice industry. The results of this study will shed light on industrial applications of continuous UV pasteurization systems. It is also expected that UV

treatment would eliminate the requirement of use of preservatives in shalgam juice in order to prevent microbial deterioration caused by yeast and molds. The negative effects of heat treatment application on the sensory quality characteristics of shalgam juice could be minimized by utilizing from UV application as an alternative method for heat treatment.

CHAPTER 2

GENERAL INFORMATION

2.1 Fermentation

The word fermentation is a term which can be used in very different meanings. For example, definitions such as "chemical reactions observed through bubbling", "transformation and alteration reactions of organic compounds" are present in the literature. In the broadest term, fermentation can be defined as "a series of energy releasing oxidation-reduction chain reactions by carbohydrates and related compounds in the absence of any external electron recipients". The last electron receptors of these reactions are the organic compounds that are created from the destruction of carbohydrates [24].

Fermentation provide many advantages to fruit and vegetables such as increasing their long-lastingness, extending their shelf life and seasonal attainability, reduction in cooking time and increase in their digestibility and nutritional value. Lactic acid fermentation, which is named as the cure of vegetables, plays a very important role in the development of foodstuffs. Vegetables become healthier and more nutritious with fermentation [25].

2.1.1 Important Microorganisms in Shalgam Fermentation

2.1.1.1 Lactic Acid Fermentation

Lactic acid bacteria (LAB) have a very important role in food technology. They are used in many food fermentation processes, for example dairy based products such as yoghurt, kefir, kumis, and vegetable based foods such as cucumber pickles and brined

green olives cereal based products such as bread, boza, tarhana as well as other foodstuffs such as wine, sausage (sujuk) and fish sauce [26, 27].

LAB are divided into two groups as homo- and hetero-fermentative [28, 29]. Homofermentative LAB (some *Lactobacillus*, *Pediococcus* and *Lactococcus*, etc.) produces lactic acid as the main product from sugars using the Embden-Meyerhof Parnas pathway (Figure 2.1) while heterofermentative LAB (some *Lactobacillus*, *Leuconostoc*, *Oenococcus* and *Weissella* etc.) produce secondary products such as ethyl alcohol, acetic acid, diacetyl and carbon dioxide together with the lactic acid as the primary end product using hexose-monophosphate (pentose phosphate pathway) (Figure 2.2) [26, 27].

Lactic acid bacteria is microorganisms that has the ability to produce lactic acid from carbohydrates (hexoses) as a result of its activity in some foods. Lactic acid bacteria is generally mesophilic bacteria and may develop at a minimum of 5°C and a maximum of 45°C. Important species develop at pH 4.0-4.5. Some species are active at pH 9.6 and others at pH 3.0 [26, 27, 24].

Some of the lactic acid bacteria are known to produce antibacterial substances. Substances such as acidophilin and lactocidin that are produced by *Lactobacillus acidophilus*, lactolin produced by *Lb. plantarum* or nisin produced by *Lc. lactis* are some of the bacteriocins that are effective against pathogenic bacteria. Among the bacteriosins produced by LAB; nisin molecules attach onto spores, reducing the heat resistance of the bacteria and thus enabling the sterilization of foodstuffs even at low temperatures [30].

The relationship between LAB and phenolic compounds has been investigated in the literature. The relationship between lactic acid bacteria and phenolic compounds is that LAB synthesizes or metabolizes phenolic compounds and is inhibited / activated in environments where phenolic compounds are found [31]. For example, *L. plantarum* can reduce quinate and shikimate in anaerobic conditions, whereas it is known that the development of *L. plantarum*, as well as other lactic acid bacteria *Lactobacillus collinoides* and *L. brevis*, are negatively affected in environments where hydroxycinnamic acid is present [32, 33]. The processes that take place during fermentation are respectively;

In the stage after fermentation, as there is no source of carbohydrates, no microbial development is observed in anaerobic conditions [34, 2].

2.1.1.2 Yeasts and Molds

Yeasts usually have cylindrical, oval, round or lemon-shaped cell morphology and can grow in a wide pH range (pH 2.0-9.0) and even in up to 18% ethyl alcohol. In the same time, many of them can easily grow in environments of 55-60 % sugar and high salt concentrations [35].

The number of yeasts in fresh vegetables is very low in the first days of fermentation. They develop especially in the primary and secondary stages. Yeasts isolated from fermented foods *(Debaryomyces* and *Candida* species) have histidine decarboxylase activity, which is greater than that observed for LAB and *Staphylococcus* [36].

Molds are heterotrophic, filamented (thread-like) and multicellular microorganisms that have spread almost everywhere in nature. Mold growth requires water, oxygen and macro elements (carbon, nitrogen, phosphorus, potassium) [37].

A number of yeast and mold species are known to be unwanted contagions for fermented foods and in the food industry. These yeasts and molds are in saprophytic nature and lead to the deterioration of the food as well as causing undesired results in the production. While yeast and molds are responsible for problems for many foods, the yeast-mold number of foods is an important microbiological quality indicator which gives information about inappropriate processing and/or storage conditions such as excessive contact with air, packaging without washing after grinding and wrong cooling or chilling processes [35].

2.1.2 Importance of Fermented Products on Human Health

Fermented vegetables are an important source of vitamins and minerals. Carbon dioxide that is produced during fermentation provides the necessary anaerobic conditions for ascorbic acid and for the vegetables to maintain their natural color [38].

While fermentation increases the digestibility of foods, it also causes the detoxification and degradation of unwanted substances such as phytate, tannin and polyphenols found in raw foods. Thus, bioavailability of protein and iron increases by fermentation [39].

It has been revealed that fermented foods produced by LAB induce certain positive changes with regards to cholesterol, one of the leading causes of coronary heart diseases. In addition, it has been reported that LAB support the production of immunoglobulin-A and gamma interferon, which are stimulated by the immune system. These hormones are known to increase the resistance of the human body against pathogens as well increasing its antitumor activity. LAB which could arrive to human intestinal system cause a reduction in the activity of enzymes found in the intestines such as β-glucuronidase, azoreductase, and nitroreductase. These enzymes are responsible for altering procarcinogen substances to a carcinogen structure. Therefore, a reduction in the activity of these enzymes causes an anticarcinogenic effect [24].

Pickles that are obtained through lactic acid fermentation have a protective effect on human health, especially in the large and small intestine. The increase in this positive effect due to consumption of live LAB cells along with pickles has been demonstrated by a number of studies [40]. An negative relationship has been reported between regular pickle consumption and asthma, skin problems and immune system problems seen in children [39].

2.2 Shalgam and Black Carrot

Scientific name of shalgam plant (Figure 1.1), is *Brassica rapa* L. and it belongs to the *Brassica* genus of the *Cruciferae* family.

Shalgam plant, although found in the traditional formula, is nowadays not prevalently used in the production of shalgam juice. Shalgam contains minerals such as iron and calcium, A, B, C group vitamins as well as soluble sugars of sucrose, fructose, and glucose. Shalgam varieties grown for human consumption are rich in terms of vitamins A, B, C as well as minerals such as calcium, magnesium iron, sulfur, iodine, and phosphorous. Its roots and leaves, due to abundancy of nutrients, apart from being used as edibles, are reported to be used colloquially as remedy for certain illnesses [41]. Due to its seasonal availability and its high processing costs, shalgam is often not used in the production of shalgam juice [4].

(a) (b)

Figure 1.1 a: Shalgam (*Brassica rapa*) and b: Black Carrot (*Daucus carota*)

Another important material used in the production of shalgam juice is black carrot (*Daucus carota*). The carrot is a two-year plant from the Umbelliferae family. This vegetable, apart from being rich in anthocyanins, also contains considerable quantities of thiamine (B1) and riboflavin (B2) vitamins. Black carrot also contains a considerable amount of sugar [5]. The nutritional properties of black carrot are given in Table 1 [5].

Table 1 Nutrition values of black carrot

Nutritional Elements	Unit	Amount*	Nutritional Elements	Unit	Amount*
General			**Vitamin**		
Water	g	88.29	Vitamin C	mg	5.9
Energy	kcal	41	Thiamine	mg	0.066
Energy	kJ	173	Riboflavin	mg	0.058
Protein	g	0.93	Niacin	mg	0.983
Total Lipid (fat)	g	0.24	Pantothenic acid	mg	0.273
Ash	g	0.97	Vitamin B-6	mg	0.138
Carbohydrate	g	9.58	Carotene, beta	mcg	8285
Fiber	g	2.8	Carotene, alpha	mcg	3477
Sugar, total	g	4.74	Tocopherols, beta	mg	0.01
Minerals					
Calcium, Ca	mg	33	Copper, Cu	mg	0.045
Iron, Fe	mg	0.30	Manganese, Mn	mg	0.143
Magnesium, Mg	mg	12	Potassium, K	mg	320
Phosphorus, P	mg	35	Sodium, Na	mg	69
Zinc, Zn	mg	0.24			
*** Chart values are for 100g of edible black carrot**					

2.2.1 Shalgam juice

In the Turkish Standard (TS 11149) revised on November 2003, shalgam juice is defined as; "A product that is obtained by mixing bulgur flour, sourdough, potable water (TS 266) and edible salt (TS 933), subjecting the mixture to lactic acid fermentation, adding şalgam (*Brassica rapa*), purple carrot (*Daucus carota*), and powdered hot pepper (TS 2419) to the obtained extract, subjecting the new mixture once again to lactic acid fermentation. Certain physicochemical properties of shalgam juice are given in Table 2 [49].

Table 2 Properties of shalgam juice

Composition	Value
Total Dry Matter	≥ 2.5% (w/w)
Total acid (in terms of lactic acid)	≥% 6.0 g/L
pH	≥ 3.3 - maximum 3.8
Lactic acid	≥ 4.5 g/L - maximum 5.5 g/L
Volatile acid (in terms of acetic acid)	≥ 0.7 g/L - maximum 1.2 g/L
Salt	≤ 2% (w/w)
Ash	≥ 1.5% (w/w)

Shalgam juice is a sour taste, red colored, blurry beverage that is obtained through lactic acid fermentation [4, 10, 42]. In fermentation, the dominant microorganisms are comprised of *Lb. sanfranciscensis, Lb. pontis, Lb. brevis, Lb. plantarum, Lb. alimentarius, Lb. fructivorans, Lb. reuteri, Lb. fermentum, S. cerevisiae*, and to a lesser degree *S. exiguous, C. krusei and C. milleri* [43, 44, 45].

The unique color of shalgam juice is due to the pigments that are transferred from black carrot [10, 46]. Shalgam juice is mainly consumed in the provinces of Adana, Hatay, Mersin, Osmaniye and Kahramanmaraş and the towns connected to these provinces, although the region it is most prevalent in is Adana and its surrounding towns. In this region, shalgam juice is served for consumption without packaged or in bottles and plastic containers. It is loved as much as other beverages and its consumption has reached considerable levels. In recent years, it has begun to be consumed in provinces such as İstanbul and Ankara as well [10, 9]. Shalgam juice harmonizes well with the foods of the region that it is consumed in and it complements them in terms of taste.

There are two kinds of shalgam juice, being spicy and non-spicy [47]. Like shalgam juice, the most important characteristic of fermented products such as pickles, pickled olives, kefir and yogurt that are produced through lactic acid fermentation. Lactic acid has a significant effect on the shelf life of these products [10, 42]. Lactic acid, in addition to giving a sour taste to shalgam juice, also provides features such as digestion facilitation, refreshing feeling, regulating the pH of the digestive system and enabling the body to benefit more from certain minerals [48]. Since many lactic acid fermented products have acidic pH levels, they are regarded as reliable products because pathogenic microorganisms cannot grow or survive [8, 42].

Shalgam juice can be homemade (traditional) or produced by commercially in Turkey. Although there is no standard method for the production of shalgam juice, generally two different methods are used. Aside from the traditional method (sourdough fermentation and carrot fermentation), there are some industrial plants that directly produce shalgam juice without dough fermentation [50]. Traditional shalgam juice production is shown in Figure 1.2 [51].

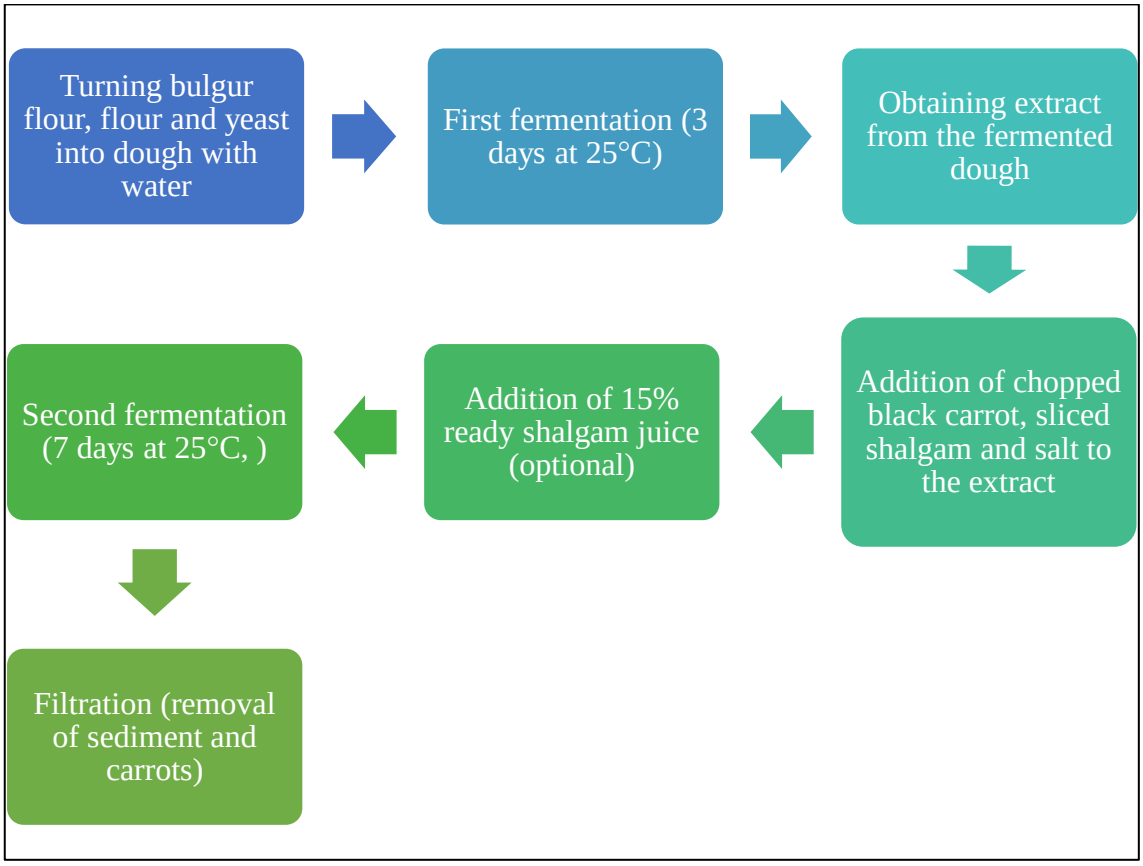


Figure 1.2 Shalgam juice production using traditional methods

The traditional shalgam juice production method consists of 2 stages, being the dough fermentation (first fermentation) and the carrot fermentation (second fermentation). In carrot fermentation, bulgur flour (3%), rock salt (0.2%) and yeast (S. cerevisiae) (0.2%) are kneaded by adding water until sufficient consistency is attained. This kneading process enables the development of flavoring compounds as well as transferring of compounds such as starch, proteins, vitamins etc. which must be extracted from the bulgur flour to the dough. This stage is completed by leaving fermentation for 3 days at room temperature. Then the microorganism load (yeasts and LAB) and water-soluble components (starch, proteins, vitamins, minerals, aromatic compounds, organic acids, etc.) found in this dough are extracted with sufficient amount of water. This liquid obtained from the first fermentation is transferred to a separate can in order to carry out the second fermentation (carrot fermentation or main fermentation). As directly adding bulgur flour without dough fermentation prevents the fermentation from being carried out as desired, this stage is widely used, however, shalgam juice production with direct fermentation (without performing dough fermentation) is also possible. The second fermentation of purple carrot (15%), shalgam (% 1), rock salt (% 1) and the water extracted from the dough is carried out at room temperature until the increase in acidity comes to a halt [46]. In this stage, the shalgam and purple carrots can be sliced in different sizes (1, 5, 9 cm etc.) or chopped and left for fermentation, or they can also be used by being mashed into a paste and passed through a rough/coarse filter. As each company has developed a specific method regarding this issue, there is no standard method of production.

2.3 UV and Effect Mechanism

Ultraviolet (UV) rays cover a small portion in the electromagnetic spectrum ranged from the 100 to 400 nm. Ultraviolet (UV) rays are divided into sub-classes as follows; UV-A (315-400 nm) which is responsible for the tanning of the human body, UV-B (280-315 nm) which causes skin burns and skin cancer, UV-C (200-280 nm) which has a germicidal effect, and Vacuum UV (100-200 nm) which can only spread in vacuum as it can be absorbed by all materials [21, 52]. Among these classes, UV-C has lethal effect against microorganisms such as bacteria, viruses, protozoa, yeast, mold, and algae [21, 17]. Figure 1.3 shows the location of the UV region in the electromagnetic spectrum.

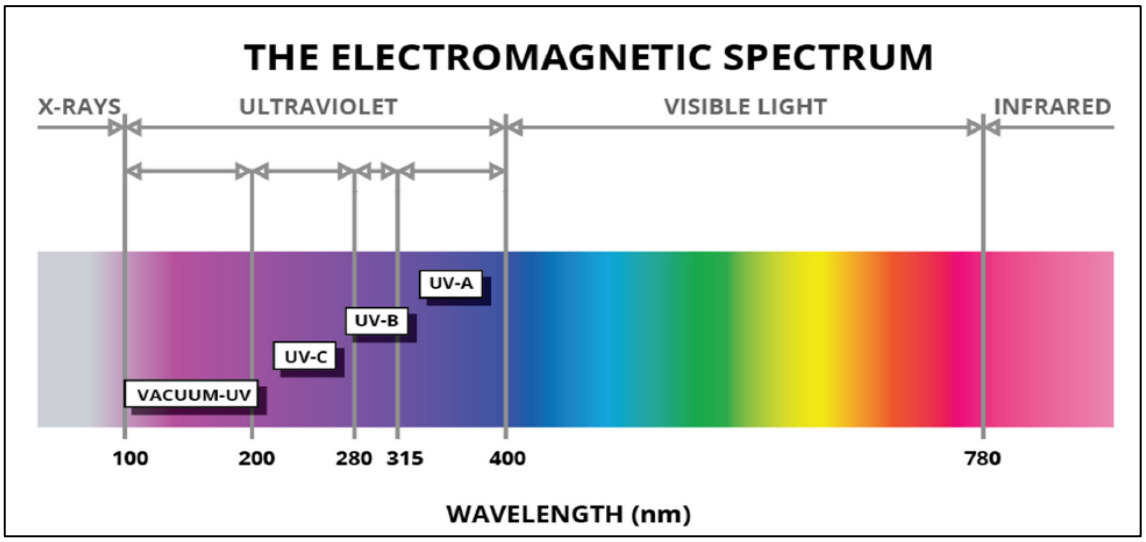


Figure 1.3 UV wavelengths [19].

2.3.1 UV Reactors

Various UV reactors have been designed to be used in fruit juices. The most important among these are the laminar flow, turbulent flow, and dean flow reactors. As can be seen in Figure 1.4, the laminar-flow UV reactor contains two nested cylinders. These cylinders revolve around their own axes. And they have low rotational speeds, and they are known as Taylor-Couette flow. There is quartz glass on the outside of the cylinders. There are aluminum reflectors on the quartz glass. Vortexes are generated as a result of the operation of the reactor and these vortexes are called Taylor vortexes [53].

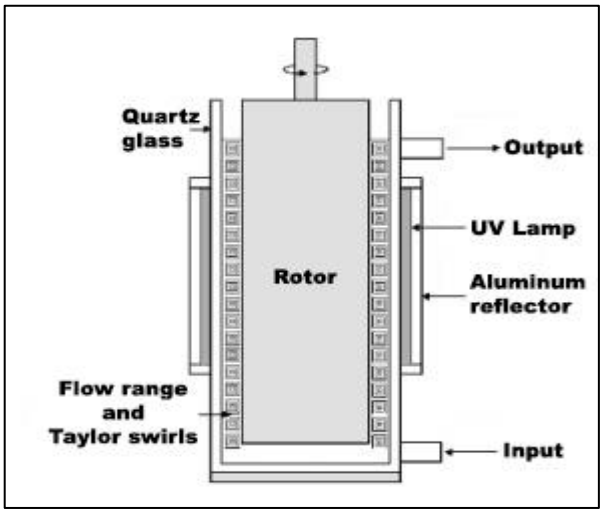


Figure 1.4 Laminar flow UV reactor [54].

The purpose in designing the turbulent flow reactor shown in Figure 1.5 was to increase the turbulence inside the rector with a homogenous and high flow rate. Thus, better results are expected by subjecting each and every point of the product to the UV process [53].

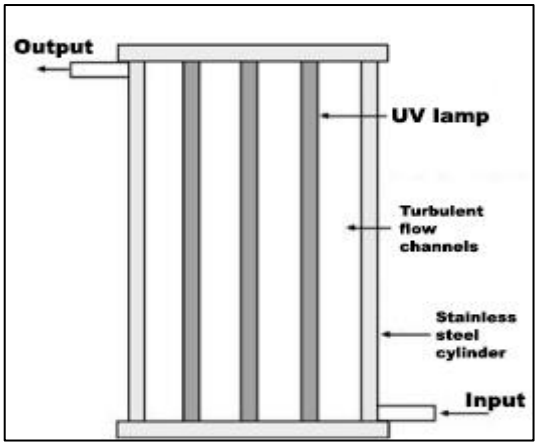


Figure 1.5 Turbulent-flow UV reactor [54].

The dean flow reactor shown in Figure 1.6, contains spirally wrapped Teflon tubes and UV lamps. There are reflectors on the inside and outside of the tube. The outer section of the reactor is made up of the stainless steel cylinder. A second vortex is created due to the spiral Teflon tubes and this is called the "Dean effect" [53].

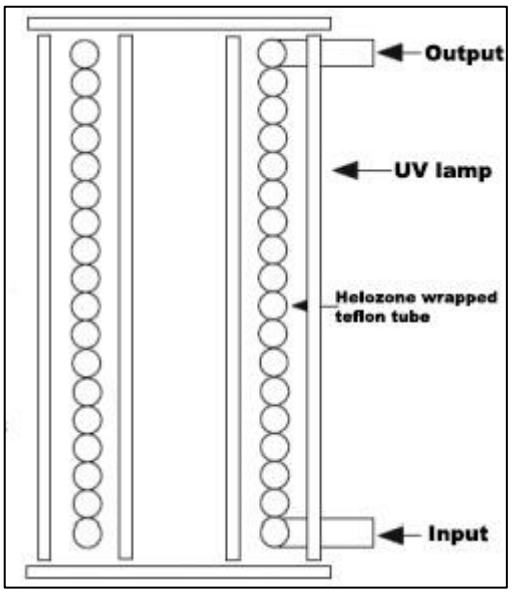


Figure 1.6 Dean-flow UV reactor [54].

The FDA approves the UV processes on the condition that turbulent flow reactors are used [52].

2.3.2 Penetration

The penetration effect of UV-C rays into the liquid depends on the liquid's UV absorption ability, brix and suspended matter content. The liquid having a high Brix value reduces the penetration concentration of the UV rays into the liquid. Large suspended particles found within the liquid reduces the effect of the UV beams on microbial [21, 19]. In addition, color components and organic compounds found in liquid foodstuffs such as fresh fruit juices and beverages cause less passage of UV radiation in comparison to water. Therefore, this low permeability reduces UV effectiveness [54]. It has been reported that as the suspended matter content and absorbance index of blurry apple juice increases, the inactivation efficiency of Escherichia coli K12 with UV rays decreases [55]. Although a correct UV reactor design is important, it has been determined that the negative effects caused by high UV absorbance and viscosity of certain liquid foods can be reduced as such, and as a result, inactivation efficiency can be increased. Also, depending on the model of flow in the UV reactor, the location and duration of suspended microorganisms in some regions within the area of application may considerably change. Therefore, the flow model is extremely effective on the total applied UV dose [53].

2.3.3 Effect of UV Treatment on Microorganisms

UV treatment shows the highest microbicidal effect with UV-C between 250-270 nm. The wavelength of 254 nm is used for the surface disinfection of certain liquid food products such as water [52] fruit juice [19, 21], milk [56], liquid egg [57, 58] and sugar solution [57].

The UV radiation energy absorbed in cellular DNA forms chemical covalent bonds between adjacent thymine bases, forming the thymine dimer. These emerging thymine dimers constitute the primary mechanism of cellular UV damage. Figure 1.3 shows the mechanism of UV treatment affecting DNA [59].

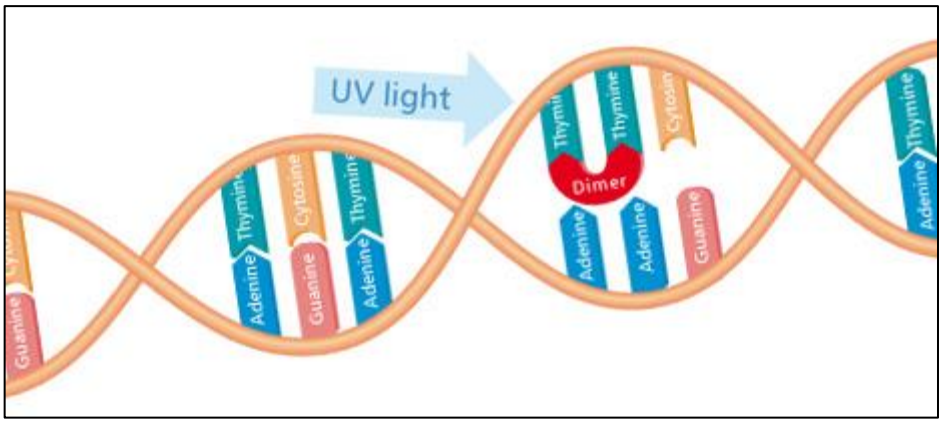


Figure 1.7 Mechanism of UV treatment effecting DNA

Damage caused by the UV treatment leads to thymine dimers causing folds in the strands of DNA and disrupting chromosome replication before cell division. Thus, the transcription of genes cannot occur. If this alteration in the thymine dimers is seen in genes that carry out vital functions, the result is lethal because DNA replication is inhibited. Most microorganisms have a repair system that is activated by light that can repair this damage in the DNA. In this system called "photoreactivation", the thymine dimers are separated from each other and revert to their original forms by enzymes which activate in visible light. In some microorganisms, there is an enzyme system called "Dark reactivation" which does not require light. In this system, short DN strands that carry thymine dimers are cut and discarded. It is thus possible for the microorganism to repair itself. Damage also increases with the increase in the intensity of the UV light. As a result, it becomes difficult for the microorganism to repair itself [59].

The UVt radiation affects the DNA of exposed microbial cell by causing the formation of thymine dimer (peptide bonds) in the DNA molecules of the microorganism, thus inactivating the growth of the microorganism [60]. Short-wave UV light (UV-C) is a radiation in the range of 200-280 nm in the UV spectrum that mainly breaks down DNA molecules that lead to inactivate spoilage microorganism [61]. The wavelength of 254 nm (UV-C) has the highest germicidal effect and it is used for the disinfection of surface water and certain food products [60].

In a study by Mansor et al., *Salmonella Typhimurium* inactivation in pineapple juice with UV-C using Dean Vortex technology was investigated. The UV doses applied to the pineapple juice were respectively 13.75, 10.37 and 10.10 mJ / cm^2. The flow rates

applied to the sample were 30, 35 and 40 Hz respectively. As UV-C dosage increases and flow rates decreases, it was concluded that the microbial load of *Salmonella typhimurium* decreased. The best (5-log cfu/mL) microbial inactivation was achieved at a flow rate of 30 Hz and dosage of 13.75 mJ/cm^2 [62].

In a study conducted by Müller et al., the effect of UV-B and UV-C applications on the shelf life and polyphenol oxidase (PPO) activity of apple and grape juices was investigated. In UV-C applied samples, 2-log cfu/mL microbial inactivation was achieved in the total aerobic microorganisms at a dose of 100.47 kJ/L, and as a result, the shelf life was increased. Browning was prevented in the samples preserved in the refrigerator by success in PPO inactivation. However, no changes in the PPO activity and product shelf life was observed in the samples that were subjected to UV-B. As a result of this study, it was concluded that the PPO inactivation of browning reactions in fruit juices could be minimized with UV-C and that shelf life could be extended [23].

In a study by Islam et al., the *in-vitro* total antioxidant activity and total phenolic content (TPC) in apple juice by UV-C were investigated. The results showed that UV-C significantly reduced concentrations of chlorogenic acid, phlorizin, and epicatechin in apple juice at commercial disinfection doses. The applied UV-C (dose of 240 mJ / cm^2) resulted in an increase in catechin concentration. In the case of sugar (glucose and fructose) concentrations, between the doses of 0 to 40 mJ / cm^2 a slight reduction was observed relative to increasing levels of exposure. However, much smaller increases were observed in doses after 40 mJ / cm^2. TPC in apple juice did not change with UV-C. While the total in-vitro antioxidant activity changed at the dose of 40 mJ / cm^2, the activity did not change at the dose of 240 mJ / cm^2. As a result of these studies, it is believed that UV-C may be an alternative to traditional heat treatments for high-quality apple juice [63].

In a study conducted by Condón-Abanto et al., the potential use of UV-C as a decontamination method in powdered foods, especially refined flours, was investigated. The lethality of this technology on *Salmonella typhimurium* and *Lactobacillus plantarum* in wheat flour and the effect mechanism of UV-C on powdered products in liquid media with different aw and turbidity values were evaluated. In the first results, a large variability in microbial inactivation of flour was observed between levels of 0.2 and 3 log. While this change was not dependent on the low water activity within starch

and flour in the laboratory and SEM analyses of contaminated flour; it was observed that the browning effect was dependent on the efficiency of the UV-C light. Based on these results, a flour processing system was designed (0.05-2.4 kg/h) with a continuous dust cloud and 12 UV-C lamps (480 W) from a 2m vertical tunnel. Inactivation between 1.7 and 4.0 log in the population of *Lb. plantarum* in flour was attained with flow rates of 2.4 and 0.2 kg / h with a maximum duration of stay of 4 seconds. When studied industrially, it is shown in this study that UV-C treatment results in a reduced level of 4 log10 in both pathogenic and destructive microorganisms in flour [64].

In a study conducted by Chen et al., the effectiveness of citric acid (0.5%) treatment, UV-C treatment, and their combined use on weight loss, hardness, phenolic compounds, browning and natural microflora of Fuji apples during cold storage was evaluated. According to the results obtained, the individual use of citric acid and UV-C as well as their combined use did not affect the total phenolic content (TPC) and hardness but increased the PPO enzyme activity in freshly cut apples. While it was observed that the use of citric acid alone intensified browning and increased weight loss in freshly cut apple; the singular use of UV or the use of UV combined with citric acid caused a decrease in the browning reaction formation and weight loss when compared to the control. The bacterial load of freshly cut apples with citric acid application alone, UV treatment and the combined use of both lead to respective reductions of 1.5; 2.1 and 2.6 log cfu/g. All treatments reduced microbial growth throughout storage and the lowest growth rate was maintained in the combined use of citric acid and UV-C treatment. In addition, an increase in total phenolic content (TPC) (epicatechin, chlorogenic acid, catechin and caffeic acid) was observed in 15-day storage compared to the control. In general, in the light of these results, it was believed that the combined use of UV and citric acid could provide a safer and more effective protection for freshly cut apples [65].

In a study conducted by Charles et al., five different types of tomato were harvested at 2 different maturity levels, exposed to a UV-C dose of 3.7 kJ / m2 and stored for 15 days. The contents of the tomatoes with regards to simple sugars (glucose, fructose, and sucrose) and organic acids (ascorbic acid, malic acid, citric acid and oxalic acid) were evaluated during the harvest as well as 10 days and 15 days after the harvest. While the sugar content of UV-C applied fruits generally decreased, the acidity had a tendency to

increase. According to analyses made on the 10th and 15th days, UV-C treatment was shown to have an important potential to enhance taste in some varieties of tomato (Makari, Lorenzo, and Balzamoth). Malic acid level was affected mostly from UV-C treatment. This effect was observed as an increase in all preserved tomato varieties and possibly played a role in the induction of the tomato defense mechanism. As a result of sensory analysis under the light of current literature, no noticeable change was found. Finally, treated tomatoes having a high level of ascorbic acid indicated that the UV-C treatment had a high potential for increasing nutrition values without changing sensory characteristics [66].

2.3.4 The Effect of UV Treatment on Sensory Characteristics

Depending on the applied treatments in fruit juice production, changes were observed in sensory characteristics. Particularly in fruit juices, applied heat treatment resulted in important changes to color and flavor in comparison to fresh fruit juices. This application that has undesired results on quality has caused the search of alternative new methods and this search has gained speed as time went on. In studies regarding non-heat UV application, it was reported that the color of the juice was only slightly affected by UV radiation or that there was no significant change in color as a result of the application [21, 18, 9, 15]. On other studies conducted on the grape, cranberry and grapefruit juices, it was observed that increasing the UV ray application duration increased the total color difference (ΔE) for all 3 fruit juices [19]. On the other hand, Keyser et al., stated that the UV application has no notable impact on the fruit juices' unique flavor, taste and aroma characteristics. These findings were supported by another study which reported that there was no significant difference between flavor between UV applied orange juice and fresh orange juice that had not been applied any treatment at all [16].

CHAPTER 3

EXPERIMENTAL STUDIES

3.1 Material

The shalgam juice used in this study was provided from Sena Food Ind.Trade.Co.Ltd. (generally known as Hacının Şalgamı). It was made by mixing bulgur flour, sourdough, potable water (TS 266), edible salt (TS 933) and purple carrot (*Daucus carota*) without adding any preservatives. In order to prevent any change in the constitution of the shalgam juice, they were subjected to the procedures right after the opening of the bottles on the same day.

3.2 Methods

3.2.1 UV Treatment

In the study, the shalgam juice samples were pasteurized with a continuous UV pasteurization device (specially designed CiderSure 3500, USA) was used (Figures 3.1 and 3.2). This device was selected for a diverse of advantages which was approved by both FDA and literature as listed: low energy consumption, easy to use, having an automated control panel and stainless-steel casing ability to elimination of *Escherichia coli* strains and control of *Salmonella* and *Cryptosporidium* strains [67]. The operating system of the device is schematized in the Figure 3.3.

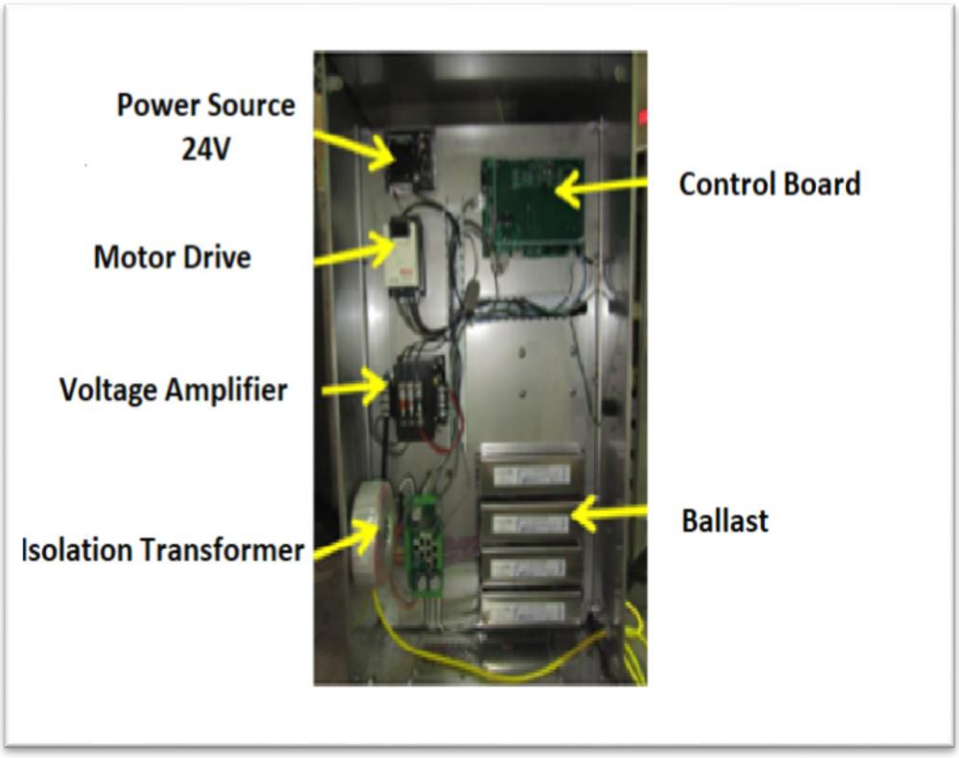


Figure 3.1 Front internal view of the 3500 CiderSure device [67]

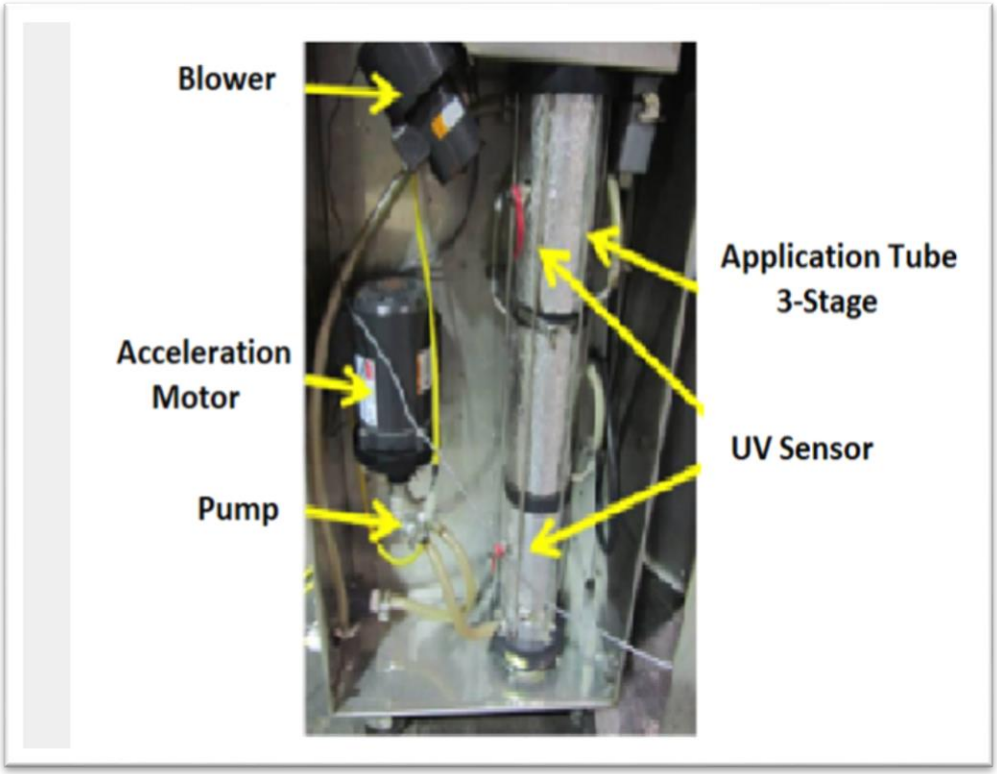


Figure 3.2 Rear internal view of the 3500 CiderSure device [67]

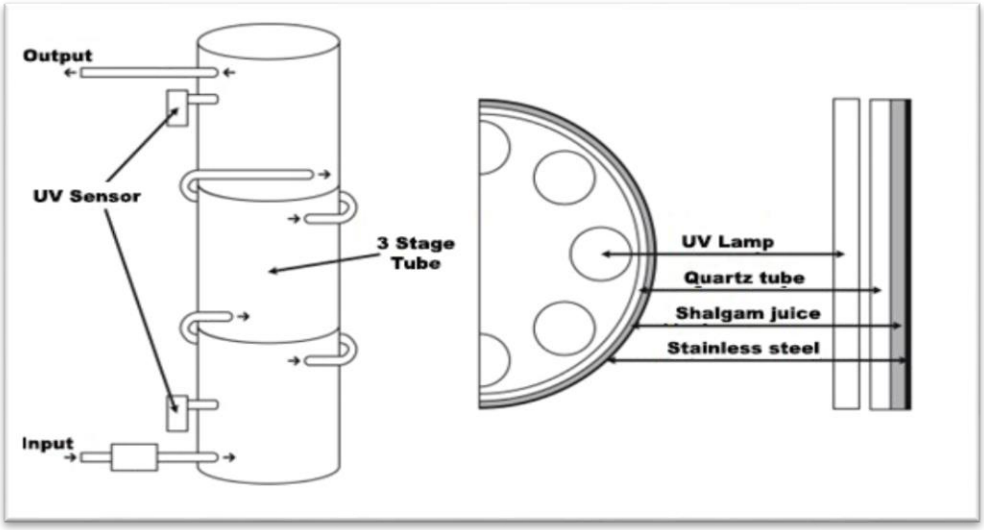
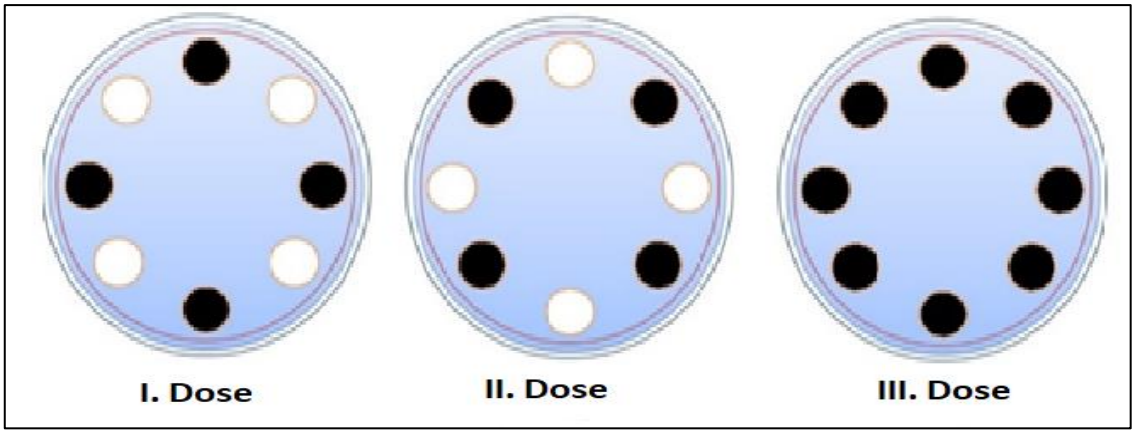


Figure 3.3 Schematic representation of Cidersure 3500 UV device [67]

3.2.2 UV Processing Conditions

In this study, shalgam juice (total 16 samples) were subjected according to microbial analyses and determined different parameters which 3 different flow rates (1.5, 2.5 and 3.5 L/min) and 3 different UV doses and 2 different temperatures (5 and 25°C). The concept dosage was organized according to the illumination of the UV lamps, where Dose I. was the dosage used for lamps numbered 1; Dose II. was the dosage used for lamps numbered 2; Dose III. was the dosage used for all lamps. The design of the UV lamps used in the study is shown in Figure 3.4. Control sample was not subjected to any pasteurization process.



5.1 mW/cm^2 5.1 mW/cm^2 10.1 mW/cm^2

Figure 3.4 The design of UV lamps

Table 3.1 UV process conditions used for shalgam juice pasteurization

Operation Sequence	Temperature (°C)	UV lamp series	UV Dose (mW/cm^2)	Flow rate (L/min)
1	5	1	5.1	1500
2	5	1+2	10.1	1500
3	25	1+2	10.1	1500
4	25	1+2	10.1	2500
5	25	1+2	10.1	3500

Clean in Place (CIP) system was used for cleaning the equipment prior to each UV application. The cleaning of the equipment with the CIP system was carried out by following the procedure:

1. Warm water (40 °C) circulation for 5 min.
2. Distilled water (~15 °C) circulation for 10 min.
3. Circulation of HCl solution (0.5 % v:v) for 10 min.
4. Distilled water (~15 °C) circulation for 10 min.
5. Circulation of NaOH solution (0.1 % w:v) for 10 min.
6. Distilled water (~15 °C) circulation for 10 min.
7. Circulation of NaCl solution (6 % w:v) for 10 min.
8. Distilled water (~15 °C) circulation for 10 min.

UV subjected shalgam juice samples were aseptically filled into sterile glass bottles (100 mL) and covered immediately. Then the samples were kept at +4°C for 5 months.

3.2.2 Heat Treatment

Only one shalgam juice sample (100 mL) was subjected to heat commercial pasteurization conditions at 72°C for 20 s using an electric heater equipped with a

temperature probe. Following the pasteurization process the sample was quickly cooled to room temperature and then stored at +4°C for 5 months.

3.2.3 Shalgam juice Storage

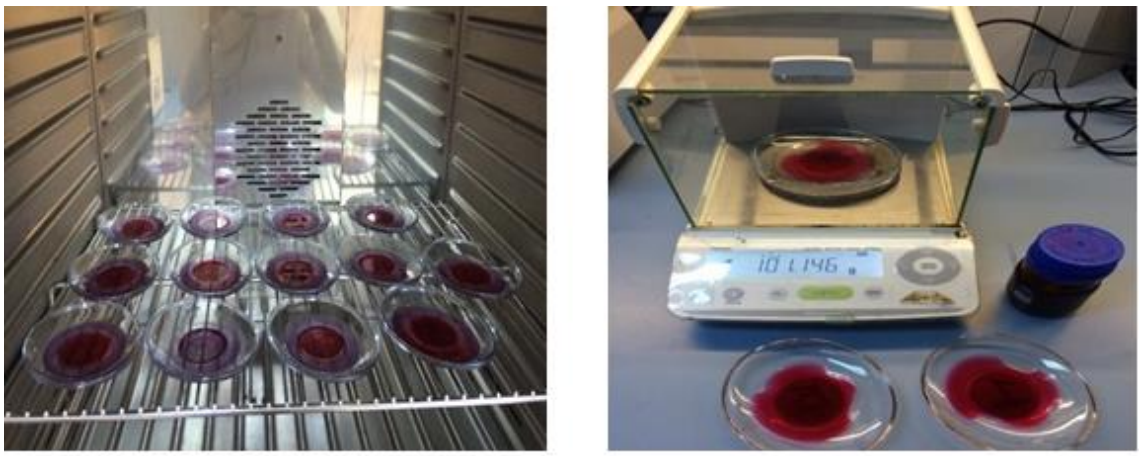
Heat or UV treated shalgam juice samples were stored at 4°C for 5 months in 100 mL glass bottles as seen in Figure 3.11. The quality analyses were performed at the days of 0, 15, 30, 60, 90, 120 and 150.

Figure 3.5 Samples prepared for storage

3.3 Physicochemical Analyses

3.3.1 Total Dry Matter

Total dry matter contents of the samples were measured gravimetrically by keeping the samples at 105 °C for 2.5 h in a drying oven (Memmert UF-110, Germany) [68].



(a) (b)

Figure 3.6 Weighing of shalgam juices in precision scales (b) oven drying (a)

3.3.2 Water Soluble Dry Matter and pH

Water-soluble dry matter contents (brix values) of the shalgam juices were determined using Abbe refractometer at 20°C. pH values of shalgam juice were measured by first calibrating a pH meter (Thermo Scientific Orion Star A111, Indonesia) with standard buffered solutions and then it was determined by submerging the pH meter electrode directly into the 22 ± 2°C sample inside the beaker [68].

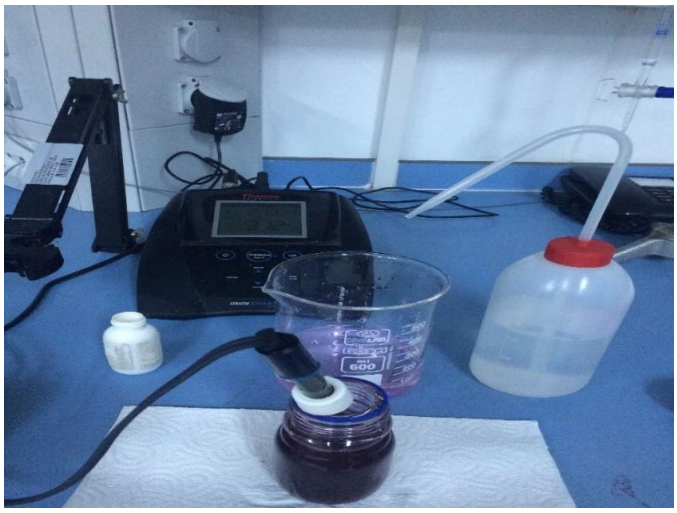
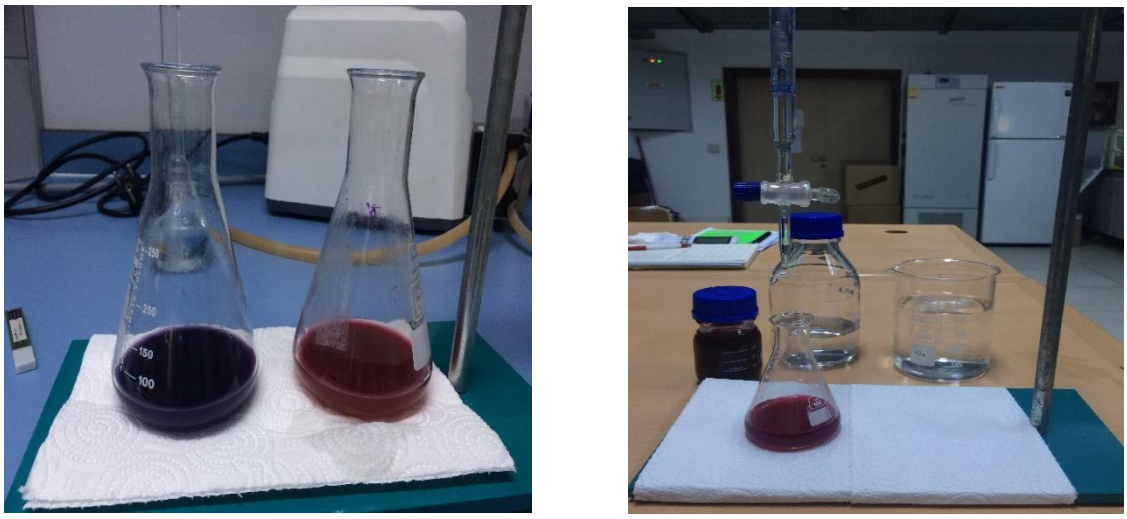


Figure 3.7 Determination of the pH of shalgam juices

3.3.3 Acidity

Titration acidity in foodstuffs is calculated in the form of the most common organic acid in the food. The method is based on the titration of the normality of the food with a certain base and the calculation of the amount of acid from the amount of base solution consumed. For the determination of acidity, samples whose storage times were completed were made into a paste by first being passed through a dicer and then a blender, later on, 10g of the sample was weighed and transferred to a 100-ml volumetric flask, the flask was then filled to the mark with distilled water. Then the volumetric flask contents were filtered through a filter paper and the filtrate was taken into a 25ml Erlenmeyer flask. After adding 2-3 drops of 1% phenolphthalein indicator, it was titrated with 0.1N NaOH solution until the permanent pink color. Acidity was calculated as % lactic acid using the following formula [68].



(a) (b)

Figure 3.8 Titration of shalgam juices with 0.1N NaOH solution (a) the final state of the titration process when the pH level reaches 8.2 (b)

Titration Acidity% = (V × F × E × 100)/M (3.1)

V: the amount of 0.1N NaOH consumed, ml

F: the factor of the base solution used in titration

E: 1 ml 0.1N NaOH equivalent of acid, g

M: the true amount of the titrated sample, ml or g

3.3.4 Color Analysis

The color properties (L*, a* and b* values) of the samples subjected to control, heat treatment and UV application was conducted with a colorimeter (Konica Minolta CR-400, Japan) (Figure 3.9). Prior to the measurement, the device was calibrated with white ceramic calibration plate and the calibration measurements were taken. Color values were defined in the form of L*, a* and b*. The L* value is the indicator of whiteness-blackness with values varying between 0 (black) and 100 (white), the a* value is the indicator of redness-greenness with values varying between of -60 (green) and +60 (red), and the b* is the indicator of blueness-yellowness with values varying between -60 (blue) and +60 (yellow) [68]. Total Color difference (ΔE) was calculated according to equation 3.2:

$$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \quad (3.2)$$

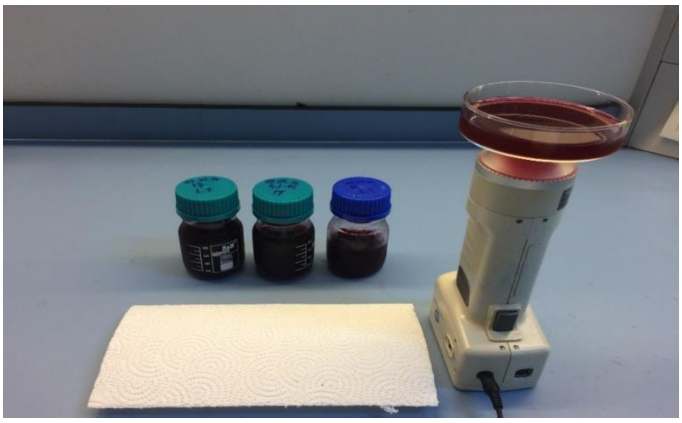


Figure 3.9 Color measurements of shalgam juices

3.3.5 Salt Content

Determination of salt content was done with the Mohr method. The method is based on the formation of tile red colored silver chromate from the added potassium chromate which is added as an indicator with the non-reacting $AgNO_3$ after the AgCl is precipitated from treating the Cl- ions found in the medium with AgNO3.

For this aim 10g of the sample was weighed from the samples whose storage times were completed and transferred to a 250ml volumetric flask, the flask was then filled to the volume with distilled water. 25ml of the mixture was transferred to an Erlenmeyer flask and neutralized with 5N NaOH. Then 1ml of 5% potassium chromate indicator (K_2CrO_4) was added and titrated with a 0.1N $AgNO_3$. Salt content was calculated from the formula 3.3.

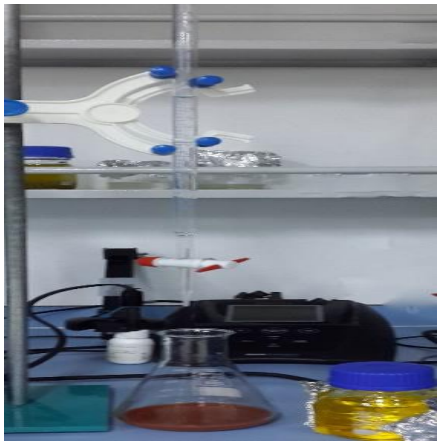


Figure 3.10 Determination of salt shalgam juices

Salt content, % = V × (f) × (0.005844) × (Dilution factor) × 100 (3.3)

V: The volume of 0.1N AgNO3 spent in titration, ml

f: the factor of 0.1N $AgNO_3$ solution

0.005844: the equivalent of 1ml of 0.1 N $AgNO_3$ solution is 0.005844 g NaCl.

3.4 Turbidity Quality Parameters

Turbidity quality of shalgam juice is determined with turbidity level and turbidity stability.

3.4.1 Turbidity Level

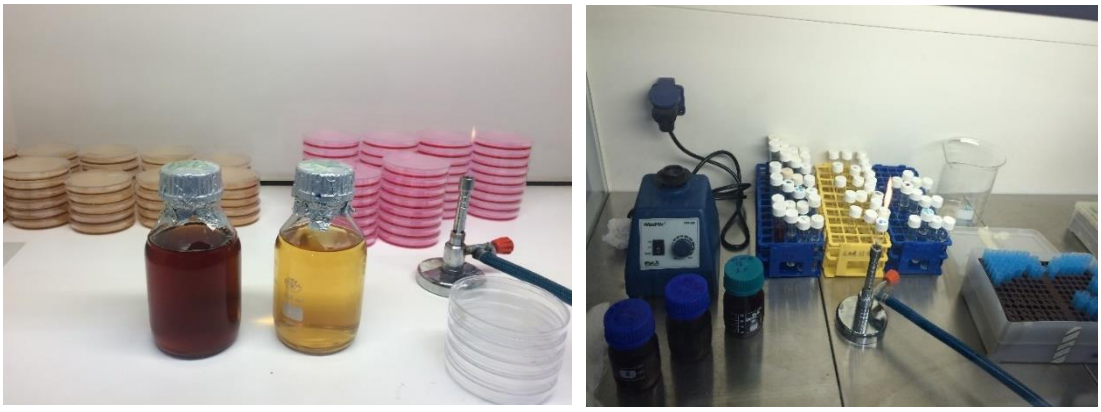
The turbidity level of shalgam juice was directly measured with a turbidimeter device (WTW Turb 355 IR Germany) after centrifuging 15ml of shalgam juice at 760xg [69].

3.4.2 Turbidity Stability

The turbidity level of shalgam juice was determined according to before and after being centrifuged at 4200xg and the turbidity stability was expressed as % by proportioning [69].

3.5 Microbiological Analysis

For this purpose total mesophilic aerobic bacteria (TMAB), total yeast-mold, total coliform and lactic acid bacteria counts were analyzed (Figure 3.12).



(a) (b)

Figure 3.11 Preparation of mediums for microbiological analyses (a) and microbiological inoculation in the sterile cabin (b)

3.5.1 Total Mesophilic Aerobe Bacteria (TMAB)

For determination of TMAB, appropriate dilutions were spread plated on PCA agar and the petri plates were incubated at 30˚C and 48 h. Then the colonies were counted

3.5.2 Total Yeast-Mold Count

Peptone water (0.01%) was used for each sample as dilution solution. The prepared peptone water was sterilized in the tubes. 25 ml of the sample was mixed with 225 ml of steril pepton water and serial dilutions were prepared. For determination of total yeast and mold. The Dichloran Rose Bengal Chloramphenicol (DRBC) Agar medium (Merck) was prepared. 0.1 ml of the sample was spread plated on DRBC Agar were left for incubation at 25°C for 5 days.

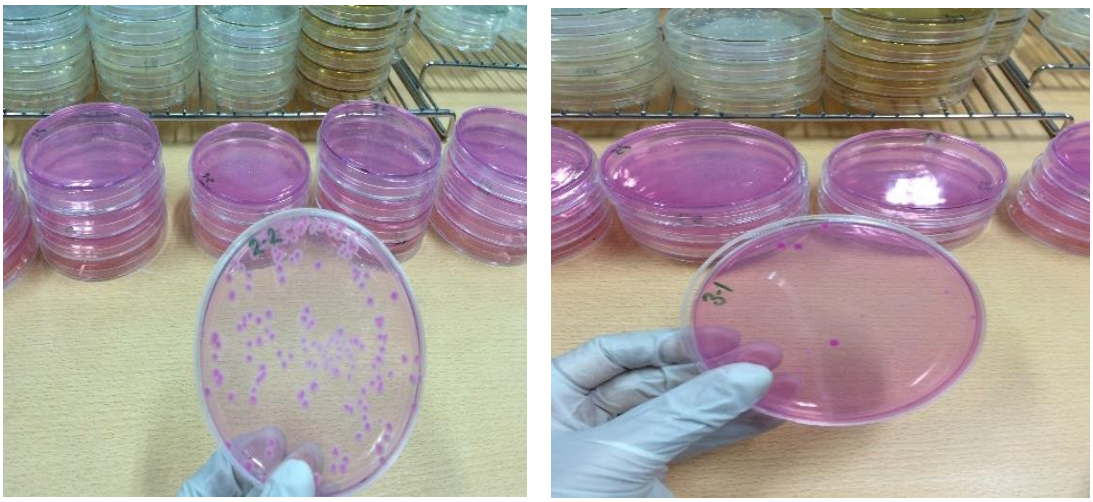


Figure 3.12 Yeast-mold count in shalgam juices subjected to different UV doses

3.5.3 Total Coliform Bacteria

For this aim, pour plate method was used. 1 ml of the dilution was poured into the petri plate and incorporated with URB Agar. After solidification of the agar, the plates were incubated at 30 °C for 48 hours. Then the purple res colonies were counted.

3.5.4 Lactic Acid Bacteria (LAB)

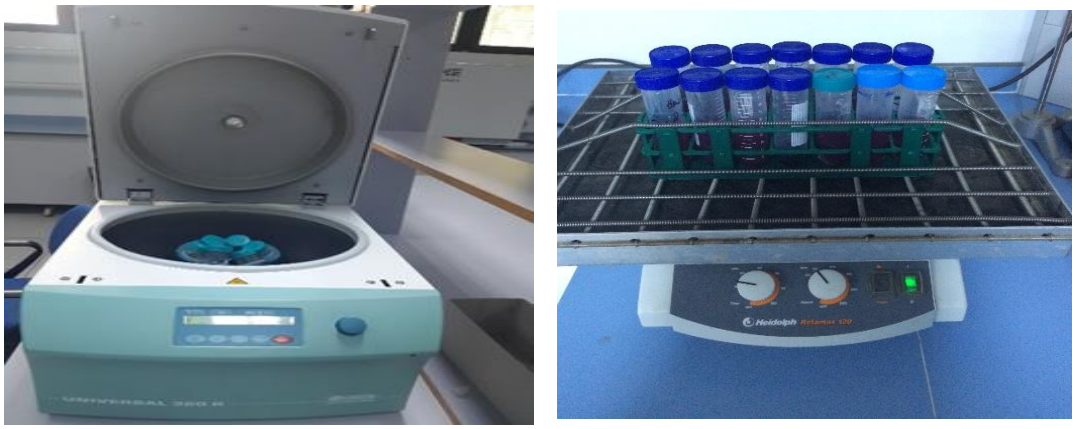
MRS agar (De Man, Rogosa, and Sharpe-MERCK) was used for determination the lactic acid bacteria (LAB) counts after incubation of spread plated petri plates at 37°C for 72 hours in both aerobic and anaerobic conditions.

3.5 Bioactive Properties

Bioactive properties, namely total phenolic content, DPPH radical scavenging activities and anthocyanin content of the samples were measured after extraction process.

3.5.1 Extraction of Phenolics

For this extraction methanol was used as solvent. 5ml of the shalgam juice was diluted with 25ml of 80% methanol. The mixtures were shaken in the shaker shown in Figure 3.14-b for 2.5 h at room temperature. Then they were filtered using filter paper and centrifuged at 4100 rpm at 25°C for 10 minutes (Hettich 320R, Germany), and if precipitation occurred, the extraction process was completed by filtering the supernatant.



(a) (b)

Figure 3.13 Incubation of homogeneous solutions at room temperature for 2.5 hours (a), filtering and centrifuging of samples after incubation (b) to obtain clear solutions

3.5.2 Total Phenolic Content (TPC)

Folin Ciocalteu procedure was used for determination of total phenolic content (TPC) based on the method described by Singleton and Rossi [70] and modified by Lie et al [71].

For this aim, 0.5ml of the sample was incorparated 2.5 ml of Folin-Ciocalteu phenol solution (0.2N). 2 mL Na_2CO_3 (7.5% W:V) was added the mixture and after 3 min the mixture was left for 30 minutes at room temperature in a dark environment. Then the absorbance values of the samples were measured at 760 nm wavelength using UV/VIS

spectrophotometer device (Shimadzu UV-1800, Japan) at Figure 3.14. The results were expressed as gallic acid equivalents (GAE), mg GAE/g, and the formula used for calculating TPC was given in Equation 3.4:

$$\text{TPC (mg/L)} = (\text{Absorbance} - 0.0821)/0.0111 \times \text{Dilution Factor} \quad (3.4)$$

(a) (b)

Figure 3.14 The UV/VIS spectrophotometer device used in the total phenolic substance quantity analysis (a) preparation of samples (b)

3.5.3 DPPH Scavenging Activity

The DPPH radical sweep method first emerged with the suggestion that the 1.1-diphenyl-2-picryl hydrazyl (DPPH) radical could be used in the determination of antioxidants, and the method was first developed by Brand-Williams et al. [72] The method was changed by Sanchez-Moreno et al. [73] and started to be used. The DPPH radical which is a dark purple colored radical turns into a DPPH reductant molecule that is a colorless compound by gaining a proton when there are antioxidants in the medium. As methanol (MERCK) was used as a solvent in the extraction processes, the DPPH solution was also prepared in methanol. In the form of 3 parallels from the extracted samples, 0.1ml was taken to each tube and methanol was placed instead of the sample as a control. 4.9 mL DPPH solution (0.1 mM) was added to each tube in 20 sec intervals and mixed with the vortex.

They were left for 20 minutes at 27°C in a dark environment for incubation. The Scavenging activity value, was calculated from obtained antiradical activity results as Trolox equivalent/g. The necessary equations were given in 3.5, 3.6.

$$\text{Scavenging activity (\%)} = [(\frac{\text{Acontrol}-\text{Asample}}{\text{Acontrol}}] \times 100 \quad (3.5)$$

Ac: Control sample absorbance value (ethanol)

As: sample absorbance value

$$\text{Trolox equivalency (mg/mL)} = [(\text{Ac-As}) - 0.0542]/1.5902 \quad (3.6)$$

3.5.4 Anthocyanin Content

The pH-differential method was used in the determination of total anthocyanin content in the samples. Centrifuged samples were mixed with pH:4.5 and pH:1 buffer solutions and absorbance values were determined at 510nm and 700nm in the spectrophotometer at which the samples showed the highest absorbance, respectively. The results were given of cyanide-3-glycoside equivalent/ml [4, 73]. The necessary equations were given in 3.7.

The total anthocyanin amount was calculated in terms

0.025 M potassium chloride buffer, pH 1.0

0.4 M sodium acetate buffer, pH4.5

$$A = (A_0 - A_{700})_{\text{pH:1.0}} - (A_0 - A_{510})_{\text{pH:4.5}} \quad (3.7)$$

3.6 Sensory Analysis

Sensory analyzes were conducted by at least 10 trained panelists to prepare 9 scale (1-9) hedonic indicators. In sensory analysis, the samples were evaluated according to appearance, taste, smell, aroma, turbidity / sediment, consistency and general taste criteria. 1 extreme evil, 9 to evaluate the scores to represent perfection. Sensory analyzes were performed on days 0, 90 days and 150 days, and the results were expressed in precious tables.

3.7 Statistical Analysis

This study was conducted in 3 parallel and 2 repeats. The data collected from the experiments were tested with one factor ANOVA against whether there was the difference between the groups by using the statistical software of SPSS 20.0 (SPSS, Inc., Chicago) for Windows was used for the statistical analysis and was determined by Duncan test with 95% confidence level.

CHAPTER 4

RESULTS AND DISCUSSION

4.1. Storage Period of Shalgam Juice Produced by Optimize Process Conditions

The UV treatment parameters were summarized in Table 4.1, the changes in quality characteristics upon UV treatment were compared to samples prepared by only with heat treatment (20 ° C at 72 ° C) and samples without any treatment (control). All samples stored for 5 months, and at the end of each month samples were analyzed for their quality characteristics and compared to controls.

Table 4.1 UV treatment applications

Operation Sequence	Temperature (°C)	UV lamp series	Flow rate (L/min)
1	5	1	1500
2	5	1 + 2	1500
3	25	1 + 2	1500
4	25	1 + 2	2500
5	25	1 + 2	3500

4.1.1 Microbial Properties

One of the important goals of this study is to reduce the microbial load by UV application. Changes in microbial properties of shalgam juice (total yeast-mold, total mesophilic-aerobic bacteria (TMAB), lactic acid bacteria (LAB) and total coliform) were determined during storage. The results obtained were compared to shalgam juice (control) which had never been treated and heat treated shalgam juice. Very important results have been achieved within the scope of the thesis's objectives.

Total yeast and mold contents and changes in LAB are presented in Tables 4.2 and 4.3. TMAB changes (Table 4.4) are also given. In addition, the total number of coliform bacteria was examined during storage for 5 months and no coliform bacteria were found (<1 cfu / mL) as a result of the treatments.

4.1.1.1 Total Mesophilic Aerobic Microorganism- TMAB

Changes in the total mesophilic aerobic microorganism (TMAB) load throughout the storage period of shalgam juice treated with various ultraviolet conditions are given in Table 4.2.

Based on the results shown in the table/chart regarding the TMAB load, it has been observed that UV application gave better results than the control conditions. After carrying out the treatments, based on the results of the storage analyses, the minimum TMAB load was observed after heat treatment. In addition, under the treatment conditions other than heat treatment and control treatment, similar results were obtained. It is seen here that TMAB values are changed in all processes except heat treatment. The microbial load in the shalgam juice was found to be as high as 7.16 log cfu/ml under control conditions.

It was found that UV-C treated and stored shalgam juices had similar TMAB load under different experimental conditions except for the control and heat treatment conditions. Heat treatment gave lower TMAB ($p<0.005$) counts than UV treatment or control. Although TMAB load increased until the 15th day regardless of the control treatment and heat treatment, it showed an overall decreasing trend starting from the 30th day. The reduction in the microbial load observed in here is thought to be correlated with the increase in the acidity of the shalgam juice after the 15th day. However, an increase in TMAB load was observed once more after the 90th day. This increase gives us information about the shelf life of shalgam juice in terms of the microbial aspect.

In the shalgam juice, continuous system ultraviolet usage, TMAB load decreased and increased compared to the days. We can explain the increase and decrease of TMAB load during storage by subletal effect.

According to the Turkish Standards Institution, the total number of mesophilic aerobic bacteria in shalgam juice should be between $1.0x10^4$ - $1.0x10^5$ cfu/ml [49]. In a study

conducted by Arıcı [51] number of TMAB of shalgam juice was found to be $2.7x10^6$-$6.1x10^7$ cfu / mL, which is higher than the values approved by TSE. Güneş [75] identified the total number of mesophilic aerobic bacteria as 7.6-8.1 log cfu / mL.

Table 4.2 Changes in the total TMAB load (log cfu/mL) during the storage period of ultraviolet -treated shalgam juice

Treatments				Storage Times (days)						
Code	Tem (°C)	UV Lamp Series	Flow Rate (L/min)	0	15	30	60	90	120	150
1	5	1	1500	4.80 ± 1.86^{Bc}	5.27 ± 0.3^{CDcd}	4.29 ± 1.5^{BCbc}	3.32 ± 0.02^{Bab}	2.99 ± 0.09^{Ba}	4.28 ± 0.26^{Dbc}	3.13 ± 0.09^{Bab}
2	5	1 + 2	1500	2.84 ± 0.33^{Aa}	3.96 ± 1.32^{BCc}	2.98 ± 0.27^{ABa}	2.75 ± 0.40^{Ba}	2.60 ± 0.08^{Aa}	3.88 ± 0.01^{Cab}	3.40 ± 0.01^{Bb}
3	25	1 + 2	1500	2.33 ± 0.08^{Aab}	4.83 ± 0.43^{BCb}	3.19 ± 0.78^{ABa}	3.26 ± 1.04^{Bab}	3.24 ± 0.42^{Bab}	4.02 ± 0.17^{Cab}	3.16 ± 0.02^{Bab}
4	25	1 + 2	2500	3.02 ± 0.15^{Aa}	4.15 ± 1.47^{BCDbc}	4.78 ± 1.44^{Cc}	2.90 ± 0.31^{Ba}	3.06 ± 0.08^{Ba}	3.62 ± 0.11^{Bab}	3.49 ± 0.02^{Cab}
5	25	1 + 2	3500	3.29 ± 0.06^{Aab}	3.69 ± 0.55^{Bbc}	4.20 ± 1.27^{BCd}	2.63 ± 0.72^{Ba}	3.31 ± 0.51^{Bab}	3.52 ± 0.09^{ABbc}	3.92 ± 0.37^{Dbc}
Control				5.87 ± 0.43^{Cc}	5.72 ± 0.16^{Dc}	7.16 ± 0.67^{De}	4.91 ± 0.55^{Cb}	4.10 ± 0.37^{Ca}	5.65 ± 0.14^{Ec}	6.51 ± 0.12^{Fd}
Heat Treatment (72°C-20s)				3.11 ± 0.08^{Ac}	1.40 ± 1.9^{Aab}	2.50 ± 0.01^{Abc}	1.17 ± 1.65^{Aa}	2.50 ± 0.05^{Abc}	3.35 ± 0.07^{Ac}	2.55 ± 0.22^{Abc}

*UV lamp series in treatments 1:5.1 mW/cm^2, 1+2: 10.1 mW/cm^2 ** Different lowercase letters indicate the significance of the statistical difference between the data on the same row according to the ANOVA Duncan test ($p<0.05$) whereas identical letters indicate that the samples are no statistical differences between the samples ($p > 0.05$). Uppercase letters indicate whether the statistical difference between the data in the same column is significant or not according to the ANOVA Duncan test. Analyze was conducted by 3 parallel for 2 replication.

4.1.1.2 Total Yeast-Mold

Changes in the total yeast-mold load throughout the storage period of shalgam juice treated with various ultraviolet conditions are given in Table 4.3.

Changes in the overall yeast-mold counts show that the minimum values were found under heat treatment conditions. Yeast-mold load under control conditions was higher than all conditions except the heat treatment conditions. At certain times during the storage period, based on the results from the same day (120th day), it was found that some conditions (UV-2) gave higher yeast-mold load than the control conditions.

It was found that UV-C treated and stored shalgam juices had similar yeast-mold load under different experimental conditions except for the control and heat treatment conditions. However, it has been observed that among these conditions, UV-3 treatment condition led to an overall more suitable and lower yeast-mold load.

When changes in total yeast-mold load throughout the storage period are analyzed, it was found that although there has been an increase until the 15th day, the values decreased after the 30th day. The yeast-mold load increased once more after the 90th day. This is considered to be correlated with the acidity of the shalgam juice. This situation is similar to TMAB load and gives us information about microbial drinkability / shelf life of shalgam juice.

In other studies on shalgam juice, total number of yeast was reported to be between $3.5x10^5$ - $4.05x10^7$ cfu / ml at the end of fermentation [51, 76, 75, 48].

Table 4.3 Changes in the total yeast-mold counts (log cfu/mL) during the storage period of ultraviolet -treated shalgam juice

Treatments				Storage time (days)						
Code	Tem (°C)	UV Lamp Series	Flow Rate (L/min)	0	15	30	60	90	120	150
1	5	1	1500	4.10 ± 0.07^{Fab}	4.76 ± 0.37^{Db}	3.80 ± 0.53^{BCa}	3.11 ± 1.51^{Ba}	3.25 ± 0.59^{BCa}	3.41 ± 0.77^{Ba}	3.50 ± 0.07^{Ca}
2	5	1 + 2	1500	2.89 ± 0.15^{Ca}	3.81 ± 0.64^{Cbc}	3.35 ± 0.29^{Bab}	3.06 ± 0.70^{Ba}	2.94 ± 0.18^{Ba}	3.98 ± 0.00^{Dc}	2.89 ± 0.37^{Ba}
3	25	1 + 2	1500	2.51 ± 0.40^{Ba}	2.84 ± 0.15^{Bab}	3.65 ± 0.65^{Bb}	2.98 ± 1.60^{Bab}	3.29 ± 0.32^{BCab}	3.63 ± 0.11^{BCDb}	2.61 ± 0.04^{Ba}
4	25	1 + 2	2500	3.29 ± 0.31^{Dab}	3.94 ± 0.33^{Cc}	3.48 ± 0.29^{Babc}	3.00 ± 0.96^{Ba}	3.24 ± 0.23^{BCab}	3.50 ± 0.11^{BCabc}	3.69 ± 0.05^{Cbc}
5	25	1 + 2	3500	3.64 ± 0.27^{Eab}	4.20 ± 0.06^{Cc}	3.74 ± 0.21^{Bb}	3.42 ± 0.25^{Ba}	3.55 ± 0.00^{CDab}	3.57 ± 0.01^{BCabc}	3.39 ± 0.34^{Ca}
Control				5.48 ± 0.02^{Gc}	6.34 ± 0.03^{Ed}	4.24 ± 0.11^{Cb}	3.82 ± 0.48^{Ba}	3.84 ± 0.05^{Da}	3.85 ± 0.09^{CDa}	3.73 ± 0.07^{Ca}
Heat Treatment (72°C-20s)				0.00 ± 0.00^{Aa}	1.59 ± 0.16^{Acd}	2.02 ± 0.17^{Ad}	0.95 ± 0.05^{Abc}	0.00 ± 0.00^{Aa}	0.00 ± 0.00^{Aa}	0.50 ± 0.01^{Aab}

*UV lamp series in treatments 1:5.1 mW/cm^2, 1+2: 10.1 mW/cm^2. ** Different lowercase letters indicate the significance of the statistical difference between the data on the same row according to the ANOVA Duncan test ($p<0.05$) whereas identical letters indicate that the samples are no statis tical differences between the samples ($p > 0.05$). Uppercase letters indicate whether the statistical difference between the data in the same column is significant or not according to the ANOVA Duncan test. Analyze was conducted by 3 parallel for 2 replication.

4.1.1.3 Lactic Acid Bacterium (LAB)

Change in LAB count of shalgam juice samples during the storage is seen in Table 4.4.

The LAB of the control was found to be 6.75 ± 0.25. In heat treated shalgam juice, LAB was completely inactive. When UV is applied, it drops to 2.99. There was a maximum of 3.74 log inactivation.

Considering the change in the LAB load, it can be said that the LAB count under the specified treatment conditions was lower ($p<0.005$) than the control group. Heat treatment provided that the complied elimination of LAB. This has been indicated as an unwanted situation for the consumption of shalgam juice. The best result in terms of LAB load was found under control treatment throughout the storage. The closest results to control treatment were found in shalgam juice treated with ultraviolet with 1500 l/min flow rate at 5 degrees, which was the UV1 condition.

In 5 conditions other than the control and heat treatment, during the first 15 days LAB load decreased but LAB count increased starting from the 30th day and this increase continued until the 90th day. Then, a decrease was observed again. This led to the TMAB results observed during the storage. Changes in the TMAB load throughout the storage period of shalgam juice treated with various ultraviolet conditions are given in Figure 4.2.

Changes in bacterial counts during fermentation in our experiments are similar to those of Gardner et al. [77] and Demir et al. [78] in terms of the reported values of vegetable juice and carrot juice.

In a study of the effects of different starting concentrations of Lactobacillus plantarum on various properties of fermented carrot juice, Demir et al. [78] found that the initial bacterial count was 3.0×10^{5} cfu / g, but increased by fermentation and reached to 4.32×10^{9} cfu / g at the end of fermentation.

Table 4.4 Changes in the total lactic acid bacteria load (log cfu/mL) during the storage period of ultraviolet -treated shalgam juice

Treatments				Stortage During (days)						
Code	Tem (°C)	UV Lamp Series	Flow Rate (L/min)	0	15	30	60	90	120	150
1	5	1	1500	4.01 ± 0.15^{Dcd}	4.06 ± 0.07^{Ed}	3.28 ± 0.01^{Cbcd}	3.11 ± 0.21^{Bbc}	3.42 ± 0.02^{Cb}	3.01 ± 0.15^{Cab}	2.17 ± 0.21^{Ba}
2	5	1 + 2	1500	3.56 ± 0.49^{Cb}	2.83 ± 0.10^{Cab}	3.18 ± 0.35^{Bb}	3.36 ± 0.03^{Bb}	2.05 ± 0.05^{Ba}	3.04 ± 0.12^{Cb}	2.23 ± 0.16^{Ba}
3	25	1 + 2	1500	2.99 ± 0.33^{Bab}	2.65 ± 0.49^{Bab}	3.24 ± 0.26^{Cb}	3.16 ± 0.15^{Bb}	3.26 ± 0.67^{b}	2.64 ± 0.14^{Cab}	2.24 ± 1.66^{Ba}
4	25	1 + 2	2500	3.29 ± 0.26^{BCb}	3.15 ± 0.52^{Cb}	3.21 ± 0.35^{BCb}	2.72 ± 0.03^{Bb}	2.76 ± 0.08^{Bb}	2.11 ± 0.11^{Ba}	1.93 ± 0.04^{Ab}
5	25	1 + 2	3500	3.49 ± 0.49^{Cc}	3.67 ± 0.04^{Dc}	3.38 ± 0.50^{Cbc}	3.07 ± 1.15^{Bbc}	3.32 ± 0.36^{Cbc}	2.80 ± 0.58^{Cab}	2.42 ± 0.14^{Ba}
Control				6.75 ± 0.25^{Ef}	6.41 ± 0.03^{Fe}	5.36 ± 0.01^{Dc}	5.17 ± 0.21^{Cbc}	6.10 ± 0.02^{Dd}	5.12 ± 0.15^{Db}	3.90 ± 0.21^{Ca}
Heat Treatments (72°C-20s)				0.00 ± 0.00^{Aa}	0.00 ± 0.00^{Aa}	0.00 ± 0.0^{Aa}	0.00 ± 0.00^{Aa}	0.00 ± 0.0^{Aa}	0.00 ± 0.0^{Aa}	0.00 ± 0.0^{Aa}

*UV lamp series in treatments 1:5.1 mW/cm^2, 1+2: 10.1 mW/cm^2. ** Different lowercase letters indicate the significance of the statistical difference between the data on the same row according to the ANOVA Duncan test ($p<0.05$) whereas identical letters indicate that the samples are no statistical differences between the samples ($p > 0.05$). Uppercase letters indicate whether the statistical difference between the data in the same column is significant or not according to the ANOVA Duncan test. Analyze was conducted by 3 parallel for 2 replication.

4.1.2 Physicochemical Properties

As a result of the physicochemical analysis on commercially available shalgam juices, salt content was found to be 1.786±0.08%, and the ash content was found to be %1.425±0.10 Changes in physicochemical properties (acidity, pH, dry matter) of shalgam juice after treatments were identified during 5 months of storage. According to these results, the acidity level was approximately 6 mg/L in terms of lactic acid whereas the pH value was approximately 3.30, and no changes have been detected yet. Dry matter contents of shalgam juices varied between 2.35±0.23% and 2.48±0.26%, and a dramatic change was not observed. L* value and chroma values partially increased compared to the beginning.

Studies by Deryaoğlu reported dry matter and ash content as 862.8-884.3 g/kg and 23.2-35.9 g/kg, respectively. In a study by Canbaş and Deryaoğlu [10], total acid content of the shalgam juices produced by traditional method was found to be between 6.95-8.19 g/L in terms of lactic acid and the pH values varied between 3.40-3.48 [79].

4.1.2.1 Total Acidity

Changes in the total acidity of shalgam juice after treatments were determined during 5 months of storage. Based on this, acidity level was found to be equivalent to approximately 6 mg/L of lactic acid.

In the study, the highest total acidity in terms of lactic acid was detected on 120th day as 7.16 mg/L, while and the lowest total acidity was 5.95 mg/L. According to the analysis of variance, no significant difference was detected between the acidity of the samples methods in terms of total acidity ($P < 0.05$). Total acidity was found to be within the limits specified in TSE standard no. 11149 on shalgam juice and complies with the standards.

Acidity is an important factor in the taste of these products. The sour taste of shalgam juice, which is a product of lactic acid fermentation, is given by the acid that forms during the fermentation [79]. According to the TSE's shalgam juice standard no. 11149, total acid content should not be less than 6 g/L in terms of lactic acid [49].

Table 4.5 Changes in the total acidity (lactic acid mg/L) during the storage period of ultraviolet -treated shalgam juice

Treatments				Storage time (days)						
Code	Tem (°C)	UV Lamp Series	Flow Rate (L/min)	0	15	30	60	90	120	150
1	5	1	1500	6.44±0.06^{ABc}	6.17±0.06^{Ab}	5.90±0.06^{Aa}	6.40±0.10^{Bc}	6.67±0.03^{Ad}	6.80±0.06^{ABd}	6.22±0.04$^{A b}$
2	5	1 + 2	1500	6.51±0.05^{Bc}	6.15±0.02^{Aa}	6.01±0.08^{ABa}	6.31±0.10^{ABb}	6.55±0.02^{Ac}	6.88±0.00^{Bd}	6.31±0.03^{Ab}
3	25	1 + 2	1500	6.51±0.02^{Bd}	6.10±0.02^{Ab}	5.90±0.06^{Aa}	6.22±0.06^{ABc}	6.67±0.03^{Ae}	6.71±0.03^{Ae}	6.26±0.05^{Ac}
4	25	1 + 2	2500	6.42±0.02^{ABc}	6.22±0.10^{Ab}	6.01±0.02^{ABa}	6.26±0.06^{ABb}	6.58±0.03^{Ad}	6.78±0.02^{Abe}	6.26±0.03^{Ab}
5	25	1 + 2	3500	6.35±0.03^{Ac}	6.15±0.11^{Ab}	5.95±0.03^{Aa}	6.31±0.03^{Abc}	6.55±0.08^{Ad}	6.82±0.05^{Abe}	6.31±0.04^{Abc}
Control				6.35±0.06^{Ab}	6.31±0.10^{Aab}	6.15±0.05^{Ba}	6.42±0.05^{ABb}	6.62±0.06^{Ac}	7.16±0.06^{Cd}	6.35±0.05^{Ab}
Heat Treatment (72°C-20s)				6.42±0.08^{ABc}	6.24±0.08^{Ab}	5.97±0.05^{Aa}	6.33±0.08^{ABbc}	6.64±0.05^{Ad}	6.80±0.03^{Abe}	6.35±0.02^{Abc}

*UV lamp series in treatments 1:5.1 mW/cm^2, 1+2: 10.1 mW/cm^2. ** Different lowercase letters indicate the significance of the statistical difference between the data on the same row according to the ANOVA Duncan test ($p<0.05$) whereas identical letters indicate that the samples are no statistical differences between the samples ($p > 0.05$). Uppercase letters indicate whether the statistical difference between the data in the same column is significant or not according to the ANOVA Duncan test. Analyze was conducted by 3 parallel for 2 replication.

4.1.2.2 pH

Change in pH shalgam juice samples during the storage is seen in Table 4.6.

According to the results of 5-month storage, pH value of the control sample varied between 3.53 and 3.48 whereas heatly treated shalgam samples had a similar change in the pH value, which varied between 3.13-3.49. The pH values of UV-treated shalgam juices varied between 3.13 and 3.49. According to the table, it can be seen that pH change was small and these changes were not significant.

In her study on the amount of black carrots added to the environment during shalgam juice production, Güneş [75] has found that the initial pH value was between 4.72 and 4.81 and the total acidity was between 0.68-0.82 g/L in terms of lactic acid; and while the total acidity increased rapidly from the beginning of fermentation, pH value decreased and the pH value at the end of fermentation was between 3.39-3.49 whereas total acidity was between 4.88-7.45 g/L.

In a study by Tiwari et al., ultrasound treatment was applied on fresh orange juice and it was found that there were no significant changes in pH, Brix and total acidity values ($P < 0.05$); whereas turbidity value, darkening index and color parameters (L, a and b) were significantly affected by the increasing ultrasound intensity [14].

On her study on shalgam juice production, İyiçınar reported that the pH values in non-pasteurized samples were initially between 3.89 -4.14 [47].

Table 4.6 Changes in the pH during the storage period of ultraviolet -treated shalgam juice

Treatments				Storage time (days)						
Code	Tem (°C)	UV Lamp Series	Flow Rate (L/min)	0	15	30	60	90	120	150
1	5	1	1500	3.46±0.01 ^{Ade}	3.46±0.05 ^{Ade}	3.35±0.00 ^{Ac}	3.43±0.01 ^{Ad}	3.20±0.01 ^{Ab}	3.12±0.00 ^{Aa}	3.49±0.06 ^{Ae}
2	5	1 + 2	1500	3.46±0.02^{ABde}	3.49±0.04 ^{Ae}	3.36±0.01 ^{ABc}	3.45±0.01 ^{Ad}	3.23±0.01 ^{Ab}	3.13±0.03 ^{Aa}	3.47±0.05 ^{Ae}
3	25	1 + 2	1500	3.47±0.01^{ABCd}	3.48±0.04 ^{Ad}	3.39±0.02 ^{Cc}	3.50±0.10 ^{Ad}	3.22±0.04 ^{Ab}	3.15±0.04 ^{Aa}	3.48±0.06 ^{Ad}
4	25	1 + 2	2500	3.49±0.02 ^{Cd}	3.45±0.04 ^{Ad}	3.36±0.01 ^{ABc}	3.50±0.08 ^{Ad}	3.20±0.00 ^{Ab}	3.13±0.04 ^{Aa}	3.49±0.07 ^{Ad}
5	25	1 + 2	3500	3.49±0.01^{BCd}	3.47±0.03 ^{Ad}	3.35±0.01 ^{Ac}	3.49±0.09 ^{Ad}	3.23±0.05 ^{Ab}	3.14±0.01 ^{Aa}	3.49±0.06 ^{Ad}
Control				3.53±0.01 ^{Df}	3.47±0.07Ade	3.38±0.03 ^{BCc}	3.44±0.03 ^{Acd}	3.21±0.01 ^{Ab}	3.08±0.11 ^{Aa}	3.48±0.06 ^{Ade}
Heat Treatment (72°C-20s)				3.49±0.03 ^{Cc}	3.47±0.05 ^{Ade}	3.37±0.02^{ABCc}	3.43±0.01 ^{Ad}	3.20±0.01^{Ab}	3.13±0.04 ^{Aa}	3.49±0.07 ^{Ae}

*UV lamp series in treatments 1:5.1 mW/cm^2, 1+2: 10.1 mW/cm^2. ** Different lowercase letters indicate the significance of the statistical difference between the data on the same row according to the ANOVA Duncan test ($p<0.05$) whereas identical letters indicate that the samples are no statistical differences between the samples ($p > 0.05$). Uppercase letters indicate whether the statistical difference between the data in the same column is significant or not according to the ANOVA Duncan test. Analyze was conducted by 3 parallel for 2 replication.

4.1.2.3 Dry Matter

Changes in the effect of ultraviolet treatment under various conditions on dry matter in shalgam juice during the storage period are given in Table 4.7.

According to the following table, it is seen that based on the UV treatment, the dry matter values in shalgam juices vary between 2.15% and 2.39%. Analysis of variance showed no statistical difference in terms of changes in dry matter between the storage periods.

It was found that the amount of change in dry matter of UV-treated shalgam juice after 5 months of storage at +4°C neither decreased nor increased compared to the control conditions and heat treatment conditions.

According to the analysis of variance results, it was found that the treatments did not result in a statistical difference on the amount of dry matter throughout the 5-month storage period. Moreover, no statistical difference was detected between the treatment conditions themselves and between the treatment conditions and control conditions during the storage period.

Table 4.7 Changes in the dry matter during the storage period of ultraviolet -treated shalgam juice

Treatments				Storage time (days)						
Code	Tem (°C)	UV Lamp Series	Flow Rate (L/min)	0	15	30	60	90	120	150
1	5	1	1500	2.34±0.02^{Aa}	2.32±0.12^{Aa}	2.22±0.11^{Aa}	2.28±0.01^{Aa}	2.25±0.02 ^{Aa}	2.27±0.03 ^{Aa}	2.43±0.28^{Aa}
2	5	1 + 2	1500	2.38±0.07^{Aa}	2.31±0.07^{Aa}	2.14±0.11^{Aa}	2.32±0.01^{Aa}	2.18±0.04 ^{Aa}	2.29±0.06 ^{Aa}	2.28±0.11
3	25	1 + 2	1500	2.15±0.19^{Aa}	2.23±0.12^{Aa}	2.18±0.07^{Aa}	2.34±0.03^{Aa}	2.17±0.01 ^{Aa}	2.16±0.17 ^{Aa}	2.37±0.20^{Aa}
4	25	1 + 2	2500	2.33±0.00^{Aa}	2.28±0.15^{Aa}	2.9±0.01 ^{Aa}	2.32±0.05^{Aa}	2.19±0.12 ^{Aa}	2.24±0.05 ^{Aa}	2.38±0.15^{Aa}
5	25	1 + 2	3500	2.32±0.12^{Aa}	2.25±0.01^{Aa}	2.29±0.03^{Aa}	2.35±0.06^{Aa}	2.17±0.04 ^{Aa}	2.39±0.02 ^{Aa}	2.34±0.21^{Aa}
Control				2.27±0.00^{Aa}	2.09±0.03^{Aa}	2.20±0.01^{Aa}	2.23±0.04^{Aa}	2.18±0.00 ^{Aa}	2.16±0.16 ^{Aa}	2.38±0.19^{Aa}
Heat Treatment (72°C-20s)				2.37±0.24^{Aa}	2.25±0.06^{Aa}	2.20±0.01^{Aa}	2.29±0.01^{Aa}	2.30±0.08 ^{Aa}	2.16±0.03 ^{Aa}	2.40±0.18^{Aa}

*UV lamp series in treatments 1:5.1 mW/cm^2, 1+2: 10.1 mW/cm^2. ** Different lowercase letters indicate the significance of the statistical difference between the data on the same row according to the ANOVA Duncan test ($p<0.05$) whereas identical letters indicate that the samples are no statistical differences between the samples ($p > 0.05$). Uppercase letters indicate whether the statistical difference between the data in the same column is significant or not according to the ANOVA Duncan test. Analyze was conducted by 3 parallel for 2 replication.

4.1.2.3 L* Value

Changes in the effect of ultraviolet treatment under various conditions on L* value in shalgam juice during the storage period are given in Table 4.8.

According to the 5 month storage results, L* values of shalgam juices treated with 1500 L/min UV at 25C (UV-3) varied between 25.19 and 35.57. Moreover, statistical difference was detected between the color values measured under this treatment condition on 30th-60th-90th day and values measured under other treatment conditions. According to the results of analysis of variance, no statistically significant difference was detected between days 0-15-120-150.

It was found that the L* values of the untreated shalgam juice varied between 29.84 and 35.53. These parameters are important for the identification of the color change in treated shalgam juice. Color values of heatly treated shalgam juice are 29.04 and 34.94. Color values of UV-treated shalgam juice are given in detail in Table 4.2. No technologically significant difference was detected in shalgam juice after UV treatment. It was found that UV treatment causes a partial decoloration, which does not have a negative impact on the natural color of the food.

Guerrero-Beltran et al. [19] have found that as the duration of UV treatment of grape, cranberry and grapefruit juices increases, the total color difference (ΔE) of all three juices also increased. On the other hand, Keyser et al. [21] found that the UV treatment had no important effect on the unique flavors of fruit juices.

Table 4.8. Changes in the L value during the storage period of ultraviolet -treated shalgam juice

Treatments				Storage time (days)						
Code	Tem (°C)	UV Lamp Series	Flow Rate (L/min)	0	15	30	60	90	120	150
1	5	1	1500	33.49 ± 0.03^{Bb}	33.98 ± 0.66^{Ab}	29.84 ± 0.27^{Ba}	29.86 ± 0.67^{Ba}	30.75 ± 1.16^{Ba}	31.79 ± 0.29^{Ba}	35.41 ± 0.33^{Ab}
2	5	1 + 2	1500	33.50 ± 0.04^{Bb}	35.66 ± 0.27^{Db}	31.06 ± 0.40^{Ba}	29.74 ± 0.66^{Ba}	31.30 ± 0.87^{Ba}	31.56 ± 0.54^{Ba}	35.10 ± 0.47^{Ab}
3	25	1 + 2	1500	33.18 ± 0.01^{Ab}	35.26 ± 0.13^{CDb}	$31.08\pm0.^{B}$	29.54 ± 0.19^{Ba}	25.19 ± 0.67^{Aa}	31.37 ± 0.40^{Aa}	35.57 ± 0.52^{Bb}
4	25	1 + 2	2500	33.15 ± 0.01^{Abc}	34.74 ± 0.24^{BCc}	29.84 ± 0.58^{Ba}	29.81 ± 0.07^{Bab}	29.97 ± 0.30^{Ba}	31.51 ± 0.37^{Ba}	35.43 ± 0.22^{Ab}
5	25	1 + 2	3500	33.09 ± 0.29^{Ab}	35.32 ± 0.49^{Db}	29.23 ± 0.23^{Aa}	29.46 ± 0.20^{Aa}	30.02 ± 0.19^{Ba}	31.45 ± 0.42^{Aa}	35.45 ± 0.01^{Ab}
Control				33.26 ± 0.26^{Abc}	34.74 ± 0.57^{BCc}	29.84 ± 0.39^{Ba}	30.01 ± 0.21^{Bab}	29.96 ± 0.32^{Ba}	31.39 ± 0.71^{Aa}	35.53 ± 0.14^{Bc}
Heat Treatment (72°C-20s)				33.15 ± 0.05^{Abc}	34.30 ± 0.16^{ABc}	29.04 ± 0.60^{Aa}	30.06 ± 0.45^{Bab}	29.44 ± 1.16^{Ba}	31.51 ± 0.21^{Ba}	34.94 ± 0.64^{Ac}

*UV lamp series in treatments 1:5.1 mW/cm^2, 1+2: 10.1 mW/cm^2. ** Different lowercase letters indicate the significance of the statistical difference between the data on the same row according to the ANOVA Duncan test ($p<0.05$) whereas identical letters indicate that the samples are no statistical differences between the samples ($p > 0.05$). Uppercase letters indicate whether the statistical difference between the data in the same column is significant or not according to the ANOVA Duncan test. Analyze was conducted by 3 parallel for 2 replication.

4.1.2.3 Chroma Value

Changes in the effect of ultraviolet treatment under various conditions on chrma value in shalgam juice during the storage period are given in Table 4.9.

In general, there has been a reduction in chroma value, analysis of variance showed that there is a significant difference between the treatments.

Chroma value of untreated control samples varied between 9.21±0.09 and 6.99±0.06, whereas it varied between 9.23±0.08 and 7.01±0.06 in heatly treated shalgam juices.

Chroma values of UV-1-treated shalgam juices varied between 914±0.01 and 6.95±0.02. Statistical difference between the chroma values during the storage period were found to be significant in an effective way. The minimum chroma level was detected on the treatment on the 150th day of storage.

Chroma levels of UV-3-treated shalgam juices were measured at regular intervals throughout the storage and they were between 9.24±0.01 and 6.92±0.02. Chroma values decreased during storage period.

Table 4.9 Changes in the chroma value during the storage period of ultraviolet -treated shalgam juice

Treatments				Storage time (days)						
Code	Tem (°C)	UV Lamp Series	Flow Rate (L/min)	0	15	30	60	90	120	150
1	5	1	1500	9.14 ± 0.01^{Ac}	8.78 ± 0.51^{Ac}	7.98 ± 0.53^{Ab}	9.19 ± 0.12^{Cc}	6.71 ± 0.59^{Aa}	7.08 ± 0.36^{Aa}	6.95 ± 0.02^{ABa}
2	5	1 + 2	1500	9.13 ± 0.01^{Ac}	8.80 ± 0.46^{Ac}	7.97 ± 0.41^{Ab}	8.96 ± 0.26^{ABc}	6.78 ± 0.36^{Aa}	6.90 ± 0.31^{Aa}	6.98 ± 0.06^{ABCa}
3	25	1 + 2	1500	9.24 ± 0.00^{Bd}	8.86 ± 0.54^{Ac}	8.13 ± 0.31^{ABb}	8.84 ± 0.03^{Ac}	6.88 ± 0.32^{Aa}	6.95 ± 0.40^{Aa}	6.92 ± 0.02^{Aa}
4	25	1 + 2	2500	9.23 ± 0.03^{Bd}	8.85 ± 0.50^{Ac}	8.27 ± 0.24^{ABCb}	8.92 ± 0.09^{ABcd}	6.64 ± 0.35^{Aa}	7.01 ± 0.37^{Aa}	7.00 ± 0.04^{BCa}
5	25	1 + 2	3500	9.18 ± 0.07^{ABe}	8.84 ± 0.55^{Ad}	7.99 ± 0.07^{Ac}	9.04 ± 0.04^{BCde}	6.43 ± 0.24^{Aa}	7.06 ± 0.25^{Ab}	7.03 ± 0.05^{Cb}
Control				9.21 ± 0.09^{Bc}	8.90 ± 0.60^{Abc}	8.64 ± 0.27^{Cb}	9.09 ± 0.13^{BCc}	6.68 ± 0.55^{Aa}	6.98 ± 0.30^{Aa}	6.99 ± 0.06^{BCa}
Heat Treatment (72°C-20s)				9.23 ± 0.08^{Bc}	8.79 ± 0.54^{Ab}	8.54 ± 0.34^{BCb}	8.91 ± 0.19^{ABbc}	6.97 ± 0.24^{Aa}	6.98 ± 0.40^{Aa}	7.01 ± 0.06^{BCa}

*UV lamp series in treatments 1:5.1 mW/cm^2, 1+2: 10.1 mW/cm^2. ** Different lowercase letters indicate the significance of the statistical difference between the data on the same row according to the ANOVA Duncan test ($p<0.05$) whereas identical letters indicate that the samples are no statistical differences between the samples ($p > 0.05$). Uppercase letters indicate whether the statistical difference between the data in the same column is significant or not according to the ANOVA Duncan test. Analyze was conducted by 3 parallel for 2 replication.

4.1.3 Turbidity

Changes in turbidity (level, quality) after the treatments performed on shalgam juice were determined during 5 months of storage (Table 4.10-4.11).

4.1.3.1 Turbidity Level

The table regarding the turbidity (sediment) level caused by the continuous UV treatment of shalgam juice is shown in Table 4.10.

The turbidity level of UV-1-treated shalgam juice had a turbidity level between 82.57±1.06 and 59.26±0.13 NTU. The minimum turbidity level was recorded on 15th day of storage. Increase in turbidity level was observed as the storage continues. But this increase was not continuous and a decrease was observed at certain time intervals. Statistical difference was observed in shalgam juices under UV-1 treatment condition during the storage period.

Considering the turbidity levels after UV-2 treatment, which was another step in ultraviolet treatment, it was found that the levels varied between 77.73±3.81 and 66.79±0.90 NTU. From the beginning until the 60th day of storage, turbidity level decreased, whereas it increased on the 60th day. This level decreased once more through the end of storage. It was found that there was statistical similarity between the control turbidity level and this treatment condition after the 30th day.

Table 4.10 Changes in the turbidity level during the storage period of ultraviolet - treated shalgam juice

Treatments				Storage time (days)						
Code	Tem (°C)	UV Lamp Series	Flow Rate (L/min)	0	15	30	60	90	120	150
1	5	1	1500	82.57 ± 1.06^{cD}	57.53 ± 2.57^{aB}	60.85 ± 5.20^{aBC}	91.43 ± 0.86^{eD}	65.90 ± 3.37^{bC}	86.94 ± 3.20^{dB}	59.26 ± 0.13^{aA}
2	5	1 + 2	1500	77.73 ± 3.81^{cC}	69.94 ± 0.27^{bD}	72.26 ± 3.64^{bA}	86.40 ± 2.72^{dABC}	70.83 ± 2.72^{bD}	91.95 ± 0.01^{eC}	66.79 ± 0.90^{aB}
3	25	1 + 2	1500	72.10 ± 1.82^{cB}	55.34 ± 1.58^{aB}	64.93 ± 4.32^{bBC}	88.09 ± 2.33^{dC}	56.15 ± 1.58^{aB}	93.76 ± 1.51^{eC}	72.13 ± 1.59^{cCD}
4	25	1 + 2	2500	87.95 ± 0.90^{eE}	68.55 ± 3.84^{bD}	71.59 ± 1.06^{cD}	87.01 ± 1.34^{eBC}	63.79 ± 1.29^{aC}	82.48 ± 1.42^{dA}	72.90 ± 1.62^{cD}
5	25	1 + 2	3500	85.81 ± 4.44^{eDE}	65.45 ± 1.42^{cC}	59.74 ± 4.15^{bC}	86.41 ± 3.61^{dABC}	73.12 ± 0.34^{eDE}	92.76 ± 4.21^{fC}	73.17 ± 2.14^{eD}
Control				74.56 ± 0.94^{Bb}	77.45 ± 1.10^{cE}	64.11 ± 2.21^{aD}	84.72 ± 1.79^{eAB}	74.68 ± 1.07^{bE}	99.26 ± 0.43^{fD}	82.23 ± 0.89^{dE}
Heat Treatment (72°C-20s)				61.41 ± 1.29^{cA}	51.04 ± 1.09^{bA}	45.44 ± 3.57^{aB}	83.77 ± 1.17^{fA}	50.27 ± 1.02^{bA}	91.04 ± 0.45^{gC}	70.49 ± 0.45^{dC}

*UV lamp series in treatments 1:5.1 mW/cm^2, 1+2: 10.1 mW/cm^2. ** Different lowercase letters indicate the significance of the statistical difference between the data on the same row according to the ANOVA Duncan test ($p<0.05$) whereas identical letters indicate that the samples are no statistical differences between the samples ($p > 0.05$). Uppercase letters indicate whether the statistical difference between the data in the same column is significant or not according to the ANOVA Duncan test. Analyze was conducted by 3 parallel for 2 replication.

4.1.3.2 Turbidity Stability

Change in the turbidity level of continuously UV-treated shalgam juices was shown in Table 4.11.

Changes in the turbidity quality of continuously UV-treated shalgam juices was between the range of change in the turbidity quality of shalgam juices under control conditions, which was 1.40 ± 0.07 % and 1.91 ± 0.06 %. Changes in the turbidity stability of heatly treated shalgam juices were between 0.85 ±0.04 % and 1.76 ±0.03 %.

Change in the turbidity quality was between 1.51±0.05% and 1.72±0.05% in UV-1-treated shalgam juice, between 1.36±0.08 % and 1.36±0.08 in UV-2-treated shalgam juice, between 1.42±0. 02% and 1.71±0.03% in UV-3-treated shalgam juice, between1.36±0.39% and 1.85±0.01 % in UV-4-treated shalgam juice, between1.17±0.46 % and 1.17±0.46 % in UV-5-treated shalgam juice.

Changes in the turbidity of shalgam juices that are continuously UV treated and then stored for 5 months at +4°C did not show a linear increase or decrease. According to the results of the statistical analysis, a difference was detected between the treatments themselves and between different treatments throughout the storage period. This difference, however, did not show an upward trend at the desired level, which resulted in failing to achieve the expected turbidity quality in shalgam juices.

Table 4.11 Changes in the turbidity stability during the storage period of ultraviolet treated shalgam juice

Treatments				Storage time (days)						
Code	Tem (°C)	UV Lamp Series	Flow Rate (L/min)	0	15	30	60	90	120	150
1	5	1	1500	1.51 ± 0.05^{Aa}	1.41 ± 0.04^{ABa}	1.51 ± 0.05^{Ba}	1.44 ± 0.13^{CDa}	1.33 ± 0.36^{Ba}	1.77 ± 0.17^{BCa}	1.72 ± 0.05^{Ba}
2	5	1 + 2	1500	1.36 ± 0.08^{Aa}	1.74 ± 0.33^{Bbc}	2.06 ± 0.08^{CDd}	1.60 ± 0.16^{Dbc}	1.32 ± 0.04^{Bab}	1.70 ± 0.11^{Bc}	1.36 ± 0.08^{Aa}
3	25	1 + 2	1500	1.42 ± 0.02^{Aab}	1.53 ± 0.07^{Bab}	1.51 ± 0.09^{Bab}	1.24 ± 0.07^{ABa}	1.23 ± 0.19^{ABa}	2.03 ± 0.55^{Db}	1.71 ± 0.03^{Bab}
4	25	1 + 2	2500	1.36 ± 0.39^{Aa}	1.84 ± 0.04^{Bb}	2.26 ± 0.04^{Dc}	1.63 ± 0.11^{Db}	1.35 ± 0.19^{Ba}	2.82 ± 0.30^{Ed}	1.85 ± 0.01^{Cb}
5	25	1 + 2	3500	1.17 ± 0.46^{Aa}	1.51 ± 0.37^{ABabc}	1.99 ± 0.50^{CDc}	1.63 ± 0.27^{Dabc}	1.23 ± 0.12^{ABab}	2.02 ± 0.08^{Dc}	1.76 ± 0.15^{Bbc}
Control				1.40 ± 0.07^{Aab}	1.58 ± 0.70^{Bab}	1.72 ± 0.09^{BCab}	1.42 ± 0.01^{CDab}	1.23 ± 0.06^{ABa}	1.98 ± 0.10^{CDb}	1.91 ± 0.06^{Cb}
Heat Treatment (72°C-20s)				0.85 ± 0.04^{Ba}	0.95 ± 0.06^{Aab}	1.10 ± 0.08^{Abc}	1.05 ± 0.15^{Abc}	1.01 ± 0.01^{Aab}	1.19 ± 0.05^{Ac}	1.76 ± 0.03^{Bd}

*UV lamp series in treatments 1:5.1 mW/cm^2, 1+2: 10.1 mW/cm^2. ** Different lowercase letters indicate the significance of the statistical difference between the data on the same row according to the ANOVA Duncan test ($p<0.05$) whereas identical letters indicate that the samples are no statistical differences between the samples ($p > 0.05$). Uppercase letters indicate whether the statistical difference between the data in the same column is significant or not according to the ANOVA Duncan test. Analyze was conducted by 3 parallel for 2 replication.

4.1.4 Bioactive Components

Changes in bioactive quality characteristics (total phenolics, total anthocyanins and DPPH antiradical activity) after continuous ultraviolet treatment of shalgam juice were determined during 5 months of storage.

4.1.4.1 Total Phenolic Content (TPC)

It can be seen in Table 4.12 that loss phenolic content after UV treatment was less compared to heat treatment. Based on these results, it was found that UV treatment is more effective in maintaining the phenolic content than the heat treatment.

TPC of control sample was 428.02 ± 0.2 to 422.68 ± 7.0 GAE mg/L. The total phenolic content of heatly treated shalgam juice was 406.19 ± 6.7 and 375.08 ± 8.3 GAE mg /L. Phenolic contents of UV-treated samples were variable.

In shalgam juices under continuous system, at the end of a 5 month storage period, the changes in the TPC were as follows: 402.06 to 471.11 GAE mg/L after UV-1 treatment, 399.50 ± 4.0 to 474.68 ± 1.9 GAE mg/L after UV-2 treatment , 398.15 ±6.1 to 481.89 ± 7.5 GAE mg/L after UV-3 treatment, 398.38 ±5.0 to 490.88 ± 11.9 GAE mg/L after UV-4 treatment, 403.86 ±4.2 to 487.35 ± 12.7 GAE mg/L after UV-5 treatment.

As well as being natural antioxidants, phenolic compounds have an important role in the formation of color, taste and aroma. Loss of phenolic content of fruit juices during the treatments is not desirable. It is a known fact that high temperature negatively affects food components. Therefore, phenolic content is expected to decrease due to heat treatment.

Phenol compounds (polyphenols) are found in fruit and vegetables in very small quantities and include substances with a -OH group attached to a benzene ring in their structure. Phenol compounds include phenol acids, flavonoids, tannins, and anthocyanins [68].

In a study by İslam et al., the effect of UV treatment on TPC was investigated. After varying doses of ultraviolet treatment from 20 mJ / cm 2 to 240 mJ / cm 2 on apple

juice, TPC was found to vary between 9.79 to 9.48 mg GAE 100 mL^{-1} . Continuous increase in UV dose did not result in a continuous decrease in TPC [63].

Phenol compounds in the shalgam juices produced by Mişoğlu, D. [80] included gallic acid, whose levels were between 557 and 682 mg / L; and in a study by Güneş, G., [75] it was found that 0Y280 index, an indicator of the phenol compounds, was between 20.7 and 36.4.

Table 4.12 Changes in the total phenol content (gallic acid equivalents mg GAE/g) during the storage period of ultraviolet -treated shalgam juice

Treatments				Storage time (days)						
Code	Tem (°C)	UV Lamp Series	Flow Rate (L/min)	0	15	30	60	90	120	150
1	5	1	1500	402.06 ± 6.2^{ABbc}	398.30 ± 8.3^{Ab}	413.69 ± 0.5^{ABd}	408.06 ± 2.8^{BCcd}	414.01 ± 2.5^{Ad}	326.00 ± 2.4^{BCa}	471.11 ± 1.5^{Ce}
2	5	1 + 2	1500	399.50 ± 4.0^{ABb}	404.49 ± 3.0^{BCc}	418.20 ± 2.2^{BCd}	404.23 ± 5.4^{ABCc}	425.33 ± 3.6^{Be}	333.00 ± 0.1^{DEa}	474.68 ± 1.9^{Cf}
3	25	1 + 2	1500	398.15 ± 6.1^{Ab}	399.73 ± 1.3^{ABbc}	410.77 ± 4.1^{Ad}	404.35 ± 3.7^{ABCc}	417.15 ± 1.7^{Ae}	324.45 ± 3.7^{Ba}	481.89 ± 7.5^{CDf}
4	25	1 + 2	2500	398.38 ± 5.0^{Ab}	398.08 ± 3.0^{Ab}	420.38 ± 1.7^{Cc}	401.68 ± 1.2^{Ab}	425.44 ± 2.9^{Bc}	336.45 ± 9.5^{Ea}	490.88 ± 11.9^{Dd}
5	25	1 + 2	3500	403.86 ± 4.2^{ABb}	400.43 ± 3.1^{ABb}	420.83 ± 5.9^{Cc}	403.71 ± 6.2^{ABb}	428.48 ± 6.4^{Bc}	356.30 ± 8.5^{Fa}	487.35 ± 12.7^{Dd}
Control				428.02 ± 0.2^{Cd}	406.56 ± 1.9^{Cc}	422.93 ± 6.6^{Cd}	399.37 ± 2.1^{Ab}	424.28 ± 0.6^{Bd}	313.15 ± 3.9^{Aa}	422.68 ± 7.0^{Bd}
Heat Treatment (72°C-20s)				406.19 ± 6.7^{Bcd}	399.95 ± 1.9^{ABc}	411.34 ± 3.4^{Ad}	409.19 ± 1.8^{Cd}	417.30 ± 9.0^{Ae}	328.00 ± 6.4^{BCa}	375.08 ± 8.3^{Ab}

*UV lamp series in treatments 1:5.1 mW/cm^2, 1+2: 10.1 mW/cm^2. ** Different lowercase letters indicate the significance of the statistical difference between the data on the same row according to the ANOVA Duncan test ($p<0.05$) whereas identical letters indicate that the samples are no statistical differences between the samples ($p > 0.05$). Uppercase letters indicate whether the statistical difference between the data in the same column is significant or not according to the ANOVA Duncan test. Analyze was conducted by 3 parallel for 2 replication.

4.1.4.2 Anthocyanin Content

As can be seen in the Table 4.13, anthocyanin content was between 5.87±0.1mg/L and 7.05±0.1 mg/L in control sample. The range of change in the total anthocyanin content of heathy treated shalgam juice was found to be between 5.82±0.1 and 6.32±0.2 mg/L.

Anthocyanin content was as follows: between 5.74±0.1 and 6.90±0.1 mg/L under UV-1 treatment, between 5.81±0.1 and 6.49±0.1 mg/L under UV-2 treatment, between 5.58±0.1 and 6.71±0.1 mg/L under UV-3 treatment, between 5.68±0.1 and 6.41±0.1 mg/L under UV-4 treatment and between 5.71±0.2 and 7.18±0.1 mg/L under UV-5 treatment. Based on the results of the analyses of variance, the statistical significance level of the amount of total anthocyanins was found to be 5%.

The attractive red color of the red colored fruit (strawberry, cherry, blackberry) and vegetable (black carrot, red beet) juices and red wine is due to the anthocyanins transferred from the raw materials. Anthocyanins are important compounds in terms of both quality and health. Anthocyanins in fruits and vegetables transfer to the product in variable amounts depending on the temperature, pH, oxygen amount, enzyme treatment, particle size, pressing process and raw material amount [4, 50]

Anthocyanins are important compounds for quality. Anthocyanins in fruits and vegetables transfer to the product in variable amounts depending on the temperature, pH, oxygen amount, enzyme treatment, particle size, pressing process and raw material amount [4, 81].

Anthocyanins are glycosides, in which an anthocyanin molecule is paired with a sugar. These are natural pigment compounds that are less soluble in water but more soluble in alcohol [4, 82]. The red color of shalgam juice is due to the anthocyanin pigments that are transferred from black carrot [10, 50].

Table 4.13 Changes in the anthocyanin content during the storage period of ultraviolet -treated shalgam juice

Treatments				Storage time (days)						
Code	Temp. (°C)	UV Lamp Series	Flow Rate (L/min)	0	15	30	60	90	120	150
1	5	1	1500	5.74±0.1^{BCcd}	4.33±0.4^{Aab}	5.58±0.3^{BCc}	3.60±2.1Aa	5.39±0.1^{BCbc}	6.08±0.1^{Ccd}	6.90±0.1^{Ed}
2	5	1 + 2	1500	5.81±0.1^{Cdc}	4.36±0.3^{Aab}	5.64±0.5^{BCbc}	3.63±2.4Aa	5.34±0.2^{Babc}	5.98±0.1^{BCc}	6.49±0.1^{Ad}
3	25	1 + 2	1500	5.58±0.1^{Aabc}	4.33±0.2^{Aa}	5.20±0.1^{Aab}	4.03±2.1Aa	5.08±0.2^{Aab}	5.90±0.3^{ABbc}	6.71±0.1^{De}
4	25	1 + 2	2500	5.68±0.1^{ABbc}	4.33±0.2^{Aa}	5.43±0.1^{ABabc}	4.19±2.0Aab	5.49±0.1^{Cabc}	6.00±0.1^{BCc}	6.41±0.1^{Bc}
5	25	1 + 2	3500	5.71±0.2^{BCabc}	4.62±0.2^{ABa}	5.49±0.2^{ABab}	3.86±2.8Aa	5.37±0.1^{BCab}	6.55±0.1^{Dbc}	7.18±0.1^{Cc}
Control				5.87±0.1^{Dbcd}	4.74±0.3^{Bb}	5.91±0.1^{Cbcd}	3.16±2.0Aa	5.69±0.1^{Dbc}	6.52±0.1^{Dcd}	7.05±0.1^{ABc}
Heat Treatment (72°C-20s)				5.82±0.1^{Cdcd}	4.35±0.4^{Aab}	5.51±0.3^{ABcd}	3.42±1.9Aa	5.14±0.2^{Abc}	5.76±0.1^{Acd}	6.32±0.2^{Fc}

*UV lamp series in treatments 1:5.1 mW/cm^2, 1+2: 10.1 mW/cm^2. ** Different lowercase letters indicate the significance of the statistical difference between the data on the same row according to the ANOVA Duncan test ($p<0.05$) whereas identical letters indicate that the samples are no statistical differences between the samples ($p > 0.05$). Uppercase letters indicate whether the statistical difference between the data in the same column is significant or not according to the ANOVA Duncan test. Analyze was conducted by 3 parallel for 2 replication.

4.1.4.3 DPPH Scavenging Activity

As can be seen in Table 4.14 the change range in the DPPH reducing the activity of shalgam juices under UV-1 treatment was between 820.24± 54.2 and 957.32 ± 16.5 mg TE / L. The change range under UV-2 treatment was between 834.89 ±54.1 and 946.08±15.1 mg /L. The change range of the DPPH reducing activity of the shalgam juices under UV-3 treatment was between 811.52 ± 32.1 and 945.91 ± 12.7 mg TE /L. It has been observed that the range of change in DPPH reducing activity of shalgam juices under UV-4 treatment within the storage period was between 784.93 ± 84.6 and 917.53 ± 21.2994 mg TE / L.

The change range of the DPPH reducing activity of the shalgam juices under control condition was between 765.20±47.9 and 919.17±6.4 mg TE /L. The change range of the DPPH reducing activity of the shalgam juices under heat treatment condition within the 5 month storage period was between 811.89±70.6 and 933.51±14.2 mg TE /L.

It was found that the maximum level of DPPH reducing activity was observed on the 15th day in all treatment conditions. The minimum levels were detected on the 60th day of storage. Statistically, there had been significant similarities between the outcomes of treatments, but considering the storage periods of each treatment, significant statistical differences were detected.

In the study conducted by Santhirasegaram et al. [83] freshly squeezed Chokanan mango juice was treated by paired combinations of sonication (for 15 and 30 min at 25 C, 40 kHz frequency) and UV-C treatment (for 15 and 30 min at 25 °C). No significant changes were observed in percentage of DPPH inhibition after heat treatment. Although heat-treated juice samples showed a decrease in reducing power (345.10 mg AAE/mL), it was non-significant when compared to the control (360.71 mg AAE/mL).

In the study conducted by Caminiti et al. [84] reported that heat treatment did not induce significant changes in antioxidant capacity of orange and carrot juice blend. However, combined treated samples (S15+U15, S30+U15 and S15+U30) exhibited significant increase in the percentage of DPPH inhibition compared to control. The highest percentage inhibition of DPPH was 91.4% (9.01 mg AAE/mL) for S30+U15 sample, compared to the control, 84.1% (8.29 mg AAE/mL).

Table 4.14 Changes in the DPPH (trolox equivalent mg TE /L) content during the storage period of ultraviolet -treated shalgam juice

Treatments				Storage time (days)						
Code	Temp (°C)	UV Lamp Series	Flow Rate (L/min)	0	15	30	60	90	120	150
1	5	1	1500	820.24±54.2^{Ab}	1010.56±85.3^{Ad}	843.33±3.5^{ABbc}	878.91±35.9^{Aa}	876.22±32.6^{BCbc}	887.22±34.0^{Ac}	957.32±16.5^{Cd}
2	5	1 + 2	1500	834.89±54.1^{Ab}	1002.95±85.6^{Ad}	859.36±11.0^{Cb}	895.92±21.9^{Aa}	887.31±21.5^{Cbc}	893.31±9.0^{Abc}	946.08±15.1^{ABcd}
3	25	1 + 2	1500	811.52±32.1^{Ab}	966.13±61.7^{Ae}	849.50±26.2^{Bbc}	816.08±40.3^{Aa}	877.45±0.6^{BCcd}	900.45±33.1^{Ad}	945.91±12.7^{Ae}
4	25	1 + 2	2500	784.93±84.6^{Ab}	1025.44±85.6^{Ae}	820.72±32.0^{Abc}	882.07±22.4^{Aa}	858.13±1.2A^{Bcd}	867.13±13.9^{Acd}	917.53±21.2^{Cd}
5	25	1 + 2	3500	826.23±48.0^{Abc}	988.68±90.2^{Ae}	818.67±45.3^{Ab}	881.69±55.5^{Aa}	870.46±3.5^{BCbc}	884.46±16.3^{Ad}	937.50±20.0^{BCde}
Control				765.20±47.9^{Ab}	1031.80±99.3^{Bd}	869.23±4.1^{Cc}	898.70±22.4^{Aa}	864.71±1.2^{ABCc}	869.71±8.2^{Ac}	919.17±6.4^{Cc}
Heat Treatment (72°C-20s)				811.89±70.6^{Ab}	962.51±61.0^{ABc}	823.19±38.9^{Ab}	939.44±30.7^{Aa}	845.80±24.4^{Ab}	855.80±38.6^{Ab}	933.51±14.2^{BCc}

*UV lamp series in treatments 1:5.1 mW/cm^2, 1+2: 10.1 mW/cm^2. ** Different lowercase letters indicate the significance of the statistical difference between the data on the same row according to the ANOVA Duncan test ($p<0.05$) whereas identical letters indicate that the samples are no statistical differences between the samples ($p > 0.05$). Uppercase letters indicate whether the statistical difference between the data in the same column is significant or not according to the ANOVA Duncan test. Analyze was conducted by 3 parallel for 2 replication.

4.1.5 Sensory Analysis

Changes in sensory quality characteristics after ultraviolet treatment applied to turnip juice are presented in Table 4.15.

According to the results, all ultraviolet applications gave better results than control and heat treatment. According to the results of ultraviolet treatment of shalgam juices 5 months storage, the best results in terms of appearance UV2, UV-3, UV-4 and it has been controlled. The worst appearance value is that of heat treatment. UV3 and UV-1, UV-2 processes are the best processes for tasting turnip juices.

The process giving the worst result in terms of taste is the application of heat treatment applied to turnip waters produced and sold in industrial size market.
In terms of odor, turnip juice had the best UV-3 value, followed by UV-4 treatment. The best organoleptic evaluation for aroma value was obtained from turnip waters from the control, UV2, and UV3 treatments. Although there is not much difference in terms of color from the operations, all the operations and control are better than the heat treatment.

When the general level of taste sensory properties of shalgam juice when looking at the best evaluation in the field of turnip juice UV-3 process conditions shalgam juice has been subjected to ultraviolet radiation. In addition to this, all the processing conditions were better than the prepared shalgam juices by heat treatment in terms of sensory properties.

Table 4.15 Changes in sensory properties of shalgam juice

Treatments				Sensory Properties							
Code	Temp (°C)	UV Lamp Series	Flow Rate (L/min)	Appearance	Taste	Odor	Aroma	Color	Turbidity	Consistency	Overall Appreciation
1	5	1	1500	8.4±0.4^{B}	8.2±0.3^{B}	7.8±0.4^{B}	8.3±0.6^{B}	8.4±0.1^{B}	7.8±0.3^{A}	7.9±0.2^{B}	8.1±0.3^{B}
2	5	1 + 2	1500	8.6±0.2^{B}	8.2±0.3^{B}	8.3±0.1^{C}	8.4±0.4^{B}	8.5±0.3^{B}	7.9±0.1^{A}	8.2±0.2^{B}	8.3±0.2^{B}
3	25	1 + 2	1500	8.7±0.3^{B}	8.4±0.5^{B}	8.4±0.3^{C}	8.4±0.7^{B}	8.5±0.2^{B}	8.2±0.2^{B}	8.1±0.3^{B}	8.4±0.2^{B}
4	25	1 + 2	2500	8.6±0.3^{B}	7.9±0.0^{B}	8.2±0.1^{C}	8.3±0.2^{B}	8.5±0.2^{B}	7.9±0.3^{B}	8.1±0.2^{B}	8.2±0.3^{B}
5	25	1 + 2	3500	8.4±0.2^{B}	8.2±0.3^{B}	7.8±0.4^{B}	7.9±0.2^{B}	8.7±0.1^{B}	8.0±0.3^{B}	8.2±0.2^{B}	8.2±0.2^{B}
Control				8.6±0.3^{B}	8.1±0.6^{B}	7.8±0.0^{B}	8.4±0.1^{B}	8.4±0.1^{B}	8.1±0.3^{B}	8.1±0.2^{B}	8.1±0.2^{B}
Heat Treatment (72°C-20s)				7.6±0.2^{A}	5.7±0.3^{A}	5.9±0.4^{A}	6.0±0.3^{A}	7.2±0.3^{A}	7.6±0.2^{A}	7.5±0.1^{A}	6.6±0.5^{A}

*UV lamp series in treatments 1:5.1 mW/cm2, 1+2: 10.1 mW/cm2.** Different lowercase letters indicate the significance of the statistical difference between the data on the same row according to the ANOVA Duncan test ($p<0.05$) whereas identical letters indicate that the samples are no statistical differences between the samples ($p > 0.05$). Uppercase letters indicate whether the statistical difference between the data in the same column is significant or not according to the ANOVA Duncan test. Analyze was conducted by 3 parallel for 2 replication.

CHAPTER 5

CONCLUSION

In this study; the shalgam juices used were obtained from an operation in Adana region. Influence of changes in the shelf life and quality characteristics of shalgam juices were investigated by applying UV treatment to shalgam juices which had no preservatives and no microbial reduction process was applied. In order to optimize according to the results of microbiological analysis, 6 different flow rates (1500-2500-3500 ml / min), 5 different operating conditions (5-25 °C) and 2 different ultraviolet intensities (5.1-10.1 mW / cm^2).

After optimization of the processing conditions (UV-1, UV-2, UV-3, UV-4, UV-5) were determined and compared with the heat treatment and control during storage. Microbiological, physicochemical and bioactive properties of the shalgam juices were investigated during 150 days of storage and to following results were obtained. Today several food processing techniques have been effectively developed which is non-heat processing methods for example, ultrasound, ultraviolet, high-hydrostatic pressure and pulsed electric field, etc.

1. This study with shalgam juices showed that ultraviolet application show that it can be an alternative to heat treatment on shalgam juice and improved the quality properties, but it could be seen that some of the targeted parts of the quality properties were not affected.
2. According to TMAB results during storage, TMAB inactivation results of UV applied shalgam juice are very close to the heat treated results (usually less than 1 log difference) and reliable results were obtained in terms of TMAB for this good value in the storage process. According to the control, in UV treated samples, lower values were obtained between 1-3 log controls. This shows that although UV is not as good as heat

treatment, it provides positive microbial safety at very good level in untreated shalgam juice.

3. As a result, while the useful LAB was completely inactivated by heat treatment applications, in UV-applied shalgam juice only 2 log reduction was observed. LAB results show that UV application can be an alternative to the adverse effects of heat treatment.
4. UV treatment at 5-25 °C on shalgam juice enabled 1-3 log decrease on total yeast and mold population.When control is compared with UV2-UV3 treatments, there is 3 log yeast mold inactivation after the treatment. At the next stages of storage, it reaches 3.5 log. When we look at the last time of storage (day 150), there is also a difference of about 1.1 log here, which is more than 90 % inactivation.
5. It was found that UV-C treated and stored shalgam juices had similar yeast-mold load under different experimental conditions except for the control and heat treatment conditions. However, it has been observed that among these conditions, UV-3 treatment condition led to an overall more suitable and lower yeast-mold load.
6. It has been found that the change in acidity level from physicochemical properties varies between 6 and 7 mg / L. This change has continued in parallel with increases in turnover waters and control during which UV treatment conditions were applied during storage.
7. There was no change in pH values of shalgam juice samples during storage for 5 months.
8. UV treatment did not cause any difference between the dry matter levels during 5 months storage.
9. The effects of UV application on continuous system in L* and chroma (C) values were analyzed by color analysis during storage time. While there was no significant difference in L values during the storage, there was a decrease in chroma value.
10. In the shalgam juice, continuous system UV usage, turbidity level and turbidity stability decreased and increased compared to the days. It is thought that this situation is caused by the short-term application of ultraviolet. It is also thought that the expected effect of turbidity level and quality is not observed in the shalgam juice during the fermentation period due to the presence of carrot particles in shalgam juice in the form of elongated grains rather than a normal fruit juice.
11. TPC exchange from the bioactive component values of shalgam juices during storage; showed some increase after the beginning of storage. The highest amount of phenolic

substance throughout storage was observed in UV-4 treatment at a flow rate of 25 °C, 2500 L / min. Studies about phenolic substances are increasing day by day. For this, researchers use different methods. TS 11149 Shalgam juice Standard can also be applied to phenolic substances and a section can be added according to the results of a number of evaluations. Thus, a clearer picture can be made by making comparisons.

12. TPC exchange from the bioactive component values of shalgam juices during storage; showed some increase after the beginning of storage. The DPPH reduction activity increased slightly compared to the storage start.
13. However, further research is needed to develop UV only activity in yeast-mold inactivation. It allows for combined applications with other non-heat modern food preservation techniques.
14. Although the process conditions of continuous system UV application are changed, the sensory evaluation results show that the results of sensory evaluation in all processing conditions give better results than heat treatment.
15. When the sensory characteristics of the products were compared, it was determined that the parameters that cause the greatest damage to the sensory characteristics were the temperature and the ultrasound severity had a much more limited negative effect.. The use of high temperatures means more loss of sensory properties. Shalgam juice exposed to UV processing were found to be more popular in general taste level.
16. Heat preservation such as pasteurization and sterilization are the most widely used to destroy microorganisms and inactivate enzymes in fruit juices. These extreme heat treatments at temperature of more than 80 °C may cause undesirable changes in various properties of fruit juices including physical, chemical, biological and organoleptic such as nutrients, color and flavor.
17. It has been found that the application of UV has a positive effect in that the heat treatment in the food is not effective. However, to ensure that the parameters such as blurring will produce better results, we can prefer to use the pastry. Continuous system with some applications can be integrated in the ultraviolet application industry for the production of fermented juice.
18. Considering the microbial and other quality characteristics, while the slower flow rate of UV is more effective, the process does not reveal any significant difference between the 5 or 25 degrees. Although the UV lamp power of 1 and 2 is the same (5.1 mW/cm^2), the results of microbial analysis show that the results are different because the localizations are different.

19. Research conducted so far suggests that UV radiation technology is promising as an alternative to heat treatment in terms of fruit juice production technology. However, there is a need for further research in some areas to improve UV activity. In particular, the development of reactors capable of achieving effective microbial reduction in fruit juices with high degree of absorptivity and viscosity and the determination of the inactivation kinetics of these reactors and pathogenic microorganisms.
20. One of the most important deficiencies in the literature, which should be taken into account in the formulation of inactivation doses, is to ensure that product quality is minimally affected by UV radiation. From this point of view, the highest level of microbial inactivation during UV application of fruit juices; there is a need for further studies involving optimizations for each fruit juice, such as bioactive compounds such as phenolic, carotenoids, and losses in aroma components and UV doses minimally provided in situations such as undesirable taste formation.
21. The combination of non-heat treatment is a novel advance for preservation of fruit juices that can efficiently inactivate microorganism led to extend shelf life while having lower impact on the organoleptic ant nutrient properties of juices in comparison with the heat process. It may be thought that the use of ultrasound, PEF, high hydrostatic pressure, and other non-heat modern food preservation methods may be effective to increase the shelf life of shalgam juices.
22. UV process can be used in combination with other food preservation methods for better retention of quality as feasible alternative to heat treatment. Overall, it has been shown these study that non-heat techniques can be helpful for food industry to produce fruit juice with high nutrient. Also, continuous system with some applications can be integrated in the UV application industry for the production of fermented juice.

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PUBLISHMENTS

Papers

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2.Dogan, K., (2017) "Evaluation with Scientific Studies of Nutrition and Food Recommendations in Prophetic Medicine" 2.World Muslim Youth Summit and Exhibition POWER 07-09 Nisan 2017, Khartoum, Sudan.

Conference Papers

1. Dogan,K., İrkilmez, M.Ü., Başlar, M., Törnük, F., (2017) "Cold pasteurization of shalgam (şalgam) juices with ultraviolet technology and determination of processing conditions" II. International Balkan Agriculture Congress 16-18 MAY 2017,Tekirdağ.

2. Dogan, K., Törnük, F., (2017) " Use of Olive Leaf as Medical and Aromatic Plant" I. International Congress On Medicinal And Aromatic Plants: "Natural And Healthy Life" 11 May 2017, Konya.

3. Dogan, K., (2017) "Evaluation with Scientific Studies of Nutrition and Food R Recommendations in Prophetic Medicine" World Muslim Youth Summit and Exhibition POWER 07-09 April 2017, Khartoum, Sudan.

4. Çevik, M., Tezcan, D., İçier F., Çakmak, K., Yılmaz, S., Dogan, K., Güneş, D., (2015) "Zeytin yaprağının arklı Güncel Kurutma yöntemleri İle Kurutulması: Kurutma Hızı ve Bazı Kalite Özellikleri Üzerine Etkilerinin Karşılaştırılması" Kurutulmuş ve Yarı Kurutumuş Gıdalar Pamukkale Gıda Sempozyumu III 13-15 May 2015, Denizli.

Projects

1. TUBITAK 214O417 Use Of Ultrasound And Ultraviolet Treatments As A New Methods At Shalgam Beverage Production Technology (TUBITAK Scholarship, 2016-2017)

2. TUBITAK 115O037 The Production of Functional Food Ingredients with Hypoglycemic Activity from Low Quality Tea Product (TUBITAK Scholarship, 2017-Continuing)