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EVALUATION OF DIFFERENT TREATMENTS ON STABILITY OF GRAPE JUICE IN SHORT-TERM STORAGE

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ABSTRACT

Grape is one of the most important crops propagated in the world. Although it is produced in high amounts, the juice is not consumed much due to some problems during storage. Acidification is one of the main problems. In this study, different treatments and durations were studied in terms of the stability of grape juice after short-term (20 days) refrigerator storage. Two types of grape juice, red and white, were evaluated according to changes in some main quality criteria. The results showed that UV-C (Ultraviolet-C) and ultrasound treatments in different concentrations and durations significantly affected the stability of grape juice. Although control showed mostly higher amounts in some properties, they were unstable and changed in very large intervals. On the contrary, treatments provided notably high stability. In light of all this information, the UV-C and Ultrasound treatments were considered crucial in terms of providing much reliable storage conditions.

Keywords: UV-C, ultrasound, grape juice, quality, shelf-life

ÖZ

KISA SÜRELİ DEPOLAMADA ÜZÜM SUYUNUN STABİLİTESİNE FARKLI UYGULAMALARIN ETKİLERİNİN DEĞERLENDİRİLMESİ

Üzüm, dünyada üretilen en önemli tarımsal ürünlerden biridir. Yüksek miktarlarda üretilmesine rağmen depolama sırasında yaşanan bazı problemler nedeniyle meyve suyu fazla tüketilmemektedir. Asitleşme bu süreçte karşılaşılan ana sorunlardan biridir. Bu çalışmada üzüm suyunun buzdolabında kısa süreli (20 gün) saklandıktan sonra stabilitesi açısından farklı işlemler ve işleme süreleri incelenmiştir. Kırmızı ve beyaz olmak üzere iki farklı üzüm suyu bazı ana kalite kriterlerindeki değişimlere göre değerlendirilmiştir. Sonuçlar farklı konsantrasyon ve sürelerde UV-C (Ultraviyole-C) ve ultrases uygulamalarının üzüm suyunun stabilitesini önemli ölçüde etkilediğini göstermiştir. Kontrol uygulaması bazı özelliklerde daha yüksek değerlere sahip olmasına rağmen, değerler kararsızdı ve çok büyük aralıklarda değiştiği görüldü. Aksine, uygulamalar oldukça yüksek stabilite sağlamıştır. Tüm bu bilgiler ışığında UV-C ve ultrases uygulamalarının güvenilir saklama koşulları sağlaması açısından oldukça önemli olduğu değerlendirilmiştir.

Anahtar Kelimeler: UV-C, ultrases, üzüm suyu, kalite, raf ömrü

INTRODUCTION

Among all fruit species, grapes are the most produced ones around the World [15]. However, its juice is not consumed in large amounts due to its high sugar and acidity content [17]. Grape juice reduces atherosclerosis heart disease threat and the formation of a platelet thrombus [20]. Purple grape juice and red wine have the same bioactive compounds, especially flavonoids in the form of flavonols [16]. Purple grape juice and wine were proofed to inhibit experimental coronary thrombosis and platelet activity [12].

Pasteurization is generally used in fruit juices to reduce the increase of microorganisms and to extend the shelf life [19]. However, due to the temperature of this process, besides the quality changes in the products, bioactive components can be denatured by ionization, hydrolysis and oxidation reactions [5]. Alternative methods that can be used instead of thermal methods are sought to obtain fruit juices of the quality and taste desired by the consumer [24]. Likewise, the increasing demand for nutritious and safe food has accelerated the spread of non-thermal techniques [6].

The new rising technologies such as pulsed electric field irradiation, microwave and ultrasound have been started to the testing for the ability to use in the food industry to obtain effective food processing methods [10]. Among these technologies, ultrasound is a sound wave that has a higher frequency than 16 kHz (above the amount of human can hear). In this technique, the sound waves moves

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through the material (solid, liquid, or gas) with a speed depending on the type of the material and wavelength [3]. UV-C (Ultraviolet-C) treatment has been used extensively to prolong the shelf-life and maintain the quality of vegetables and fruits (Chemat and Khan, 2011; Urban et al., 2016).

Although UV-C and ultrasound treatments are studied in many plants and herbal products, the effect of these treatments on the stability of grape juice has not been studied sufficiently. This study was conducted to determine the effect of UV-C and ultrasound treatments on some basic quality criteria of different grape juices.

MATERIAL AND METHOD

Preparation of Fruit Juice

Red and white grape juice were obtained from autochthonous grapes of Bolu province. The grapes harvested at maturity were brought to the laboratory, cleared of damaged and rotten grains and washed. The washed grapes were squeezed with the help of an automatic juicer and their juice was separated. The extracted juice was passed through filter paper again to clear the solid phase. Prepared fruit juices were put into 100 mL glass bottles for treatments.

Ultrasound Treatment

Fruit juices in 100 mL glass bottles were subjected to ultrasound treatment at 40°C for three different times (15, 20 and 25 minutes). HY brand (Öztiryakiler, Turkey) ultrasonic machine was used in the application. The power and resonation frequency of the device was 35 W and 42 KHz, respectively. The water reservoir of the ultrasound device was 4 liters and only six bottles were subjected to ultrasound treatment at a time to prevent overflow of the water and to ensure a whole and uniform contact.

UV-C Treatment

UV-C irradiation was applied to grape juices at a distance of 30 cm (x), 60 cm (2x) and 90 cm (3x) for 10 minutes [21]. The technical information of the UV-C lamp used in the experiment is as follows: Electrical data: Nominal voltage 96.00 V, Lamp voltage 96.00 V, Construction voltage 96.00 V, Nominal current 0.36 A, Lamp current 0.36 A, Nominal wattage, 30.00, Photometric data: Luminous intensity 7800 cd, Emitted power 200-280 nm (UVC) 12 W.

Measurement of Properties

The TSS (total soluble solids) was determined using a portable refractometer (ATC Bx40, Turkey) and reported as °Brix. pH content was measured with a table-type pH meter (Thermo Orion Star A211, USA). Titratable acidity (TA) was determined by the titration method. In the analysis, 0.1 N NaOH was added as drop by drop to 5 ml grape juice until the final pH comes to 8.1. After that, the amount of the spent NaOH recorded and TA was calculated with the equation reported by [9]. The tartaric acid equivalent was used in the calculation. Color properties were measured by a hand-type colorimeter (PCE CSM 1, UK) as L*, a*, b, Chroma* and Hue°.

Data Analysis

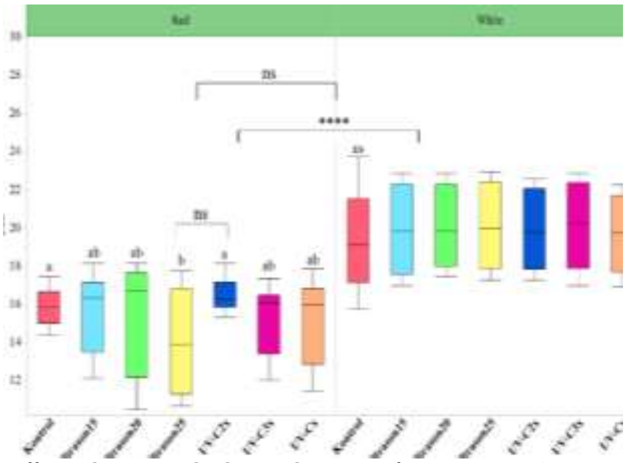
All treatments were carried out in triplicates. ANOVA (analysis of variance) was used to evaluate the data in treatments and determine the difference between different colored fruit juices. Interaction analysis was used to determine whether the effects of the treatments vary according to colors. Statistics were carried out with the R Studio statistical software [1].

RESULTS AND DISCUSSIONS

Changes in Phsyco-Chemical Properties

The effects of the treatments on the TSS amount of grape juice were found to be insignificant in both cultivars. However, TSS content varied significantly between different colored grape juice ($p<0.0001$). Color × Treatment interaction was found to be insignificant (Figure 1). Although the effect of treatments was not significant on TSS content, the variance in red-colored grape juice was significant (ANOVA, $p<0.05$). The amount of TSS in white grape juice, on the other hand, varied slightly and showed a stable appearance. Among all components of fruit juice, sugars are the main quality criteria attributing and influencing the acceptance of consumers to a product. The TSS consists of 80-90% of the total sugars in the grape juice [23]. In this perspective, treatments are relatively preferable (especially in white grapes) in the short-term preservation of grape juices in the preservation and stability of TSS content. Our results also supported [22, 27] who reported very limited changes with these treatments. On the other hand, the importance of these processing techniques in ensuring the stability of fruit juice microbial activity should not be underestimated

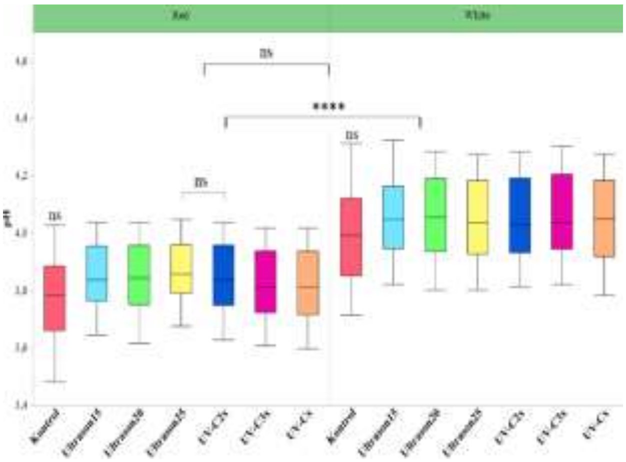
[14]. The TSS contents in all treatments were presented in Table 1.



Different letters on the bars indicate significant variance (ANOVA, p<0.05). ns: not significant. ****: significant at the level of p<0.0001.

Figure 1. The changes in TSS according to treatments and colors of grape juice

The pH content in red grape juice was significantly lower than in white (p<0.0001). The effects of the treatments and the treatment × color interaction on the pH content were not statistically significant. The variance in colors was also insignificant (Figure 2). Although the effect of the treatments on the amount of TA was found to be insignificant, the TA contents of the treatments were much more stable than the control. There was a significant difference between different colored fruit juices in terms of TA content (p<0.0001). The TA content of the red juice was generally higher. Color × treatment innervation was statistically insignificant (Figure 3). With the increase of temperature in storage conditions, limits of pH also increase and microbial spoilage accelerates [13]. In addition, a more ideal environment is created for the harmful microorganisms to live in must and wine. Consistent with our study, [26, 13] reported that UV-C treatment on grape juices stored under refrigerator conditions did not cause any statistical change in pH, TSS and TA content on the 14th day.



ns: not significant. ****: significant at the level of p<0.0001.

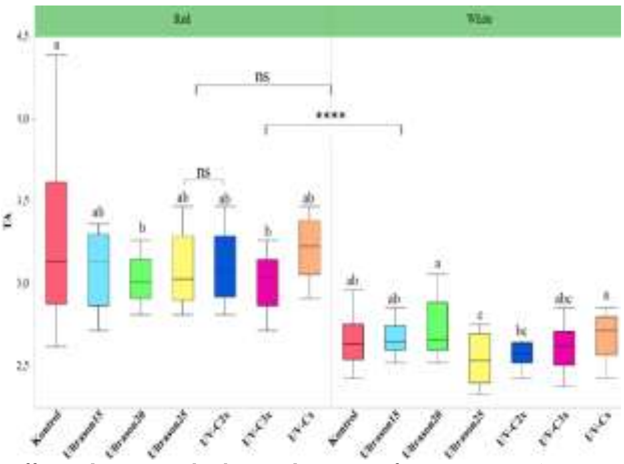
Figure 2. pH contents according to different juice colors and treatments

Table 1. Changes in the fruit juice properties in terms of different treatments

Traits	Colors	Control	Ultrasound			UV-C		
			15	20	25	x	2x	3x
TSS	Red	15.85±0.23 a*	15.70±0.60 ab	15.49±0.85 ab	14.05±0.83 b	15.25±0.64 ab	16.49±0.25 a	15.35±0.54 ab
	White	19.39±0.61 ns	19.91±0.68	20.03±0.64	20.08±0.67	19.66±0.60	19.88±0.64	20.11±0.67
pH	Red	3.77±0.04 ns	3.85±0.04	3.86±0.04	3.86±0.03	3.82±0.04	3.84±0.04	3.82±0.04
	White	4.00±0.04 ns	4.06±0.04	4.06±0.04	4.04±0.04	4.00±0.04	4.05±0.05	4.06±0.04
TA	Red	3.29±0.13 a	3.09±0.07 ab	3.03±0.04 b	3.09±0.07 ab	3.21±0.05 ab	3.11±0.06 ab	3.01±0.05 b
	White	2.66±0.03 ab	2.67±0.03 ab	2.73±0.05 a	2.54±0.05 c	2.69±0.04 a	2.57±0.02 bc	2.62±0.04 abc
L*	Red	41.22±3.16 a	31.34±2.19 b	30.75±2.23 b	33.06±3.10 b	33.22±3.11 b	30.26±2.57 b	31.09±2.70 b
	White	56.59±3.32 a	45.81±1.56 b	46.35±1.73 b	50.50±2.68 ab	43.47±3.25 b	47.44±1.37 b	48.06±2.29 b
a*	Red	25.19±1.71 a	19.85±1.91 b	20.52±1.4 b	21.2±0.93 b	20.65±0.58 b	18.49±1.17 b	17.75±1 b
	White	11.30±0.87 ns	10.76±1.51	10.27±1.45	12.05±1.36	11.39±1.02	12.04±1.37	12.05±1.37
b*	Red	19.72±3.26 ns	12.60±2.79	12.50±2.97	15.28±3.89	15.11±3.75	11.60±3.34	11.98±3.19
	White	22.57±1.34 ns	19.77±2.14 ab	18.62±1.48 ab	16.32±1.48 b	18.82±1.60 ab	20.36±2.32 ab	20.90±1.68 ab
Chroma	Red	34.81±1.50 a	25.94±0.71 bcd	26.31±0.58 bcd	28.79±1.64 b	28.00±1.62 bc	24.36±1.36 cd	23.72±1.32 d
	White	23.73±1.41 ns	22.54±2.59	21.35±1.98	20.54±1.77	22.01±1.89	23.74±2.67	24.32±2.10
Hue°	Red	35.19±5.76 b	32.45±7.57 b	30.03±7.27 b	31.99±7.78 b	31.14±7.35 b	117.86±42.15 a	29.50±7.82 b
	White	63.26±1.51 a	62.36±1.11 a	62.55±1.70 a	53.98±2.80 bc	48.37±5.71 c	59.32±0.56 ab	60.80±1.27 ab

*Values in the same line are significantly different (ANOVA, p<0.05). ns: not significant.

As it was in TSS, UV-C and ultrasound treatments had slight effects on pH and TA and mostly made these properties more stable. TSS, pH and TA are used in calculating the maturity index, which is one of the main quality criteria in grapes (Kaya and Özdemir, 2105). The main problem in grape juice is acidification over time [25]. High acidity level affects not only the eating quality of table grapes but also the suitability of the grapes for wine production [18]. As can be clearly seen in Figures 2 and 3, the treatments helped these features become more stable. Previous researchers reported similar results to ours [20]. Treatments are considered to be crucial in preventing the degradation of organic acids by reducing microbial activity in long-term storage. Because the breakdown process of biochemical compounds during shelf-life/fermentation is led by yeasts [2] and these techniques reduce their activity.

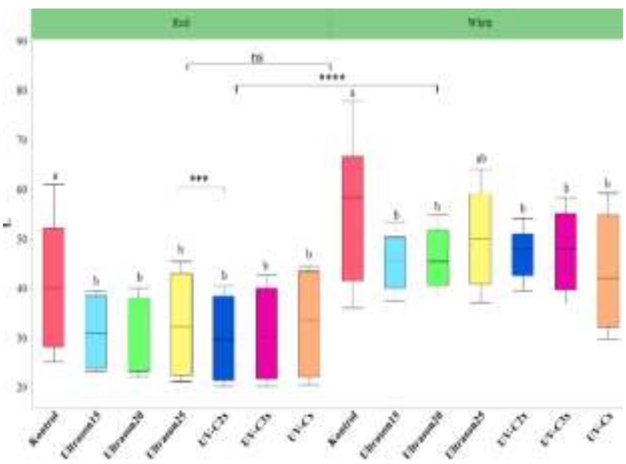


Different letters on the bars indicate significant variance (ANOVA, $p<0.05$). ns: not significant. ****: significant at the level of $p<0.0001$.

Figure 3. The contents of TA in different grape juices and treatments

Effects of Treatments on Color Properties

Brightness (L value) was determined the highest in the control group in both color grape juice. Ultrasound treatment has increased the brightness of both grape juices with the increasing treatment time. In the UV-C treatment, the highest vivid color was at the lowest dose in both fruit juices. The effects of the treatments on the brightness of the grape juice were statistically significant ($p<0.001$). There was a statistical difference between colors ($p<0.0001$) and white grape juice was brighter than red. Color × treatment interaction was insignificant (Figure 4).

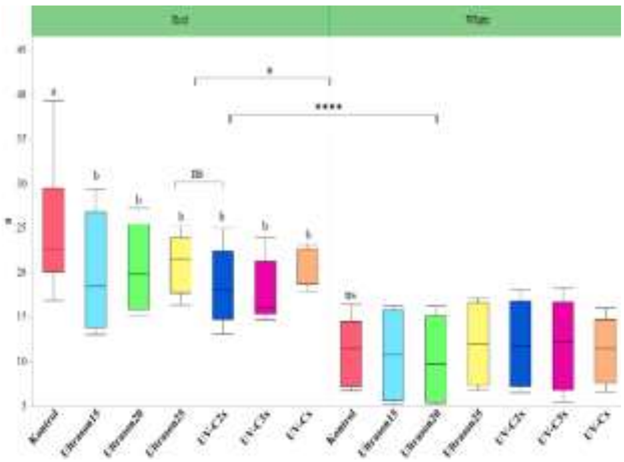


Different letters on the bars indicate significant variance (ANOVA, $p<0.05$). ns: not significant. ***, ****: significant at the level of $p<0.001$ and $p<0.0001$, respectively.

Figure 4. Changes in L value according to juice color and treatments

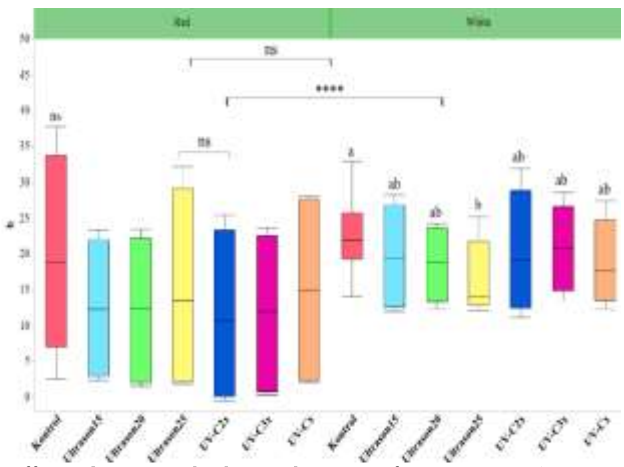
The a* value varied slightly between treatments and the effects of the treatments were insignificant. Differences between juice colors in terms of a* value was statistically significant ($p<0.0001$). Color × treatment interaction was also statistically significant ($p<0.05$). While there was a statistical difference among the a* values of the treatments in red grape juice (ANOVA, $p<0.05$), the variance in white grape juice was insignificant (Figure 5).

The effects of the treatments on the b* value were insignificant. The effect of color × treatment interaction was also negligible. There was a statistical difference between different colors of juice in terms of b* value ($p<0.0001$). White grape juice generally had higher b* values and was more stable. In red grape juice, b* values varied over a wide range in all treatments. While the variance between b* values was insignificant in red juice, it was significant in the white (ANOVA, $p<0.05$). Figure 6 shows the change of b* values in detail.



Different letters on the bars indicate significant variance (ANOVA, $p<0.05$). ns: not significant. *, ****: significant at the level of $p<0.05$ and $p<0.0001$, respectively.

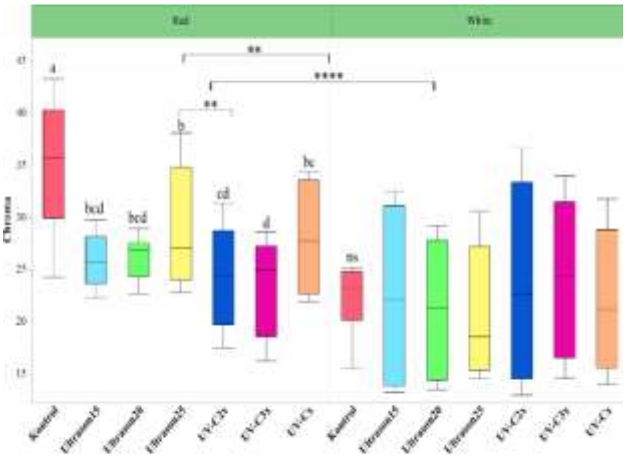
Figure 5. The a* values of red and White grape juice according to treatments



Different letters on the bars indicate significant variance (ANOVA, $p<0.05$). ns: not significant. ****: significant at the level of $p<0.0001$.

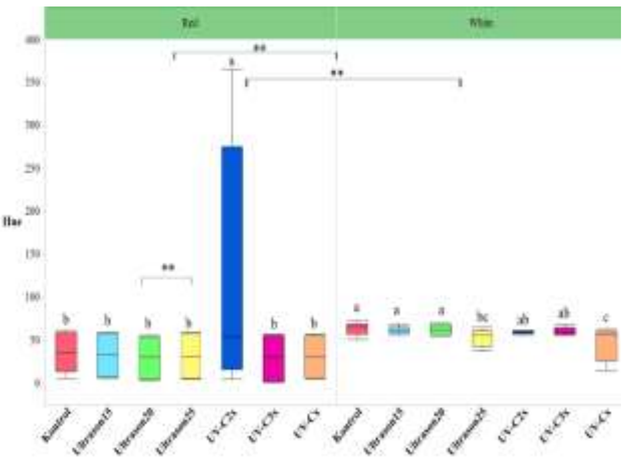
Figure 6. The changes in b* values by treatments

Chroma* and Hue° values were statistically affected by both the treatments and colors as well as color × treatment interaction (p<0.01). In terms of chroma, red grape juice had higher values in almost all treatments, while white grape juice had higher values in terms of Hue° angle except UV-C2x treatment (Figures 7 and 8).



Different letters on the bars indicate significant variance (ANOVA, p<0.05). ns: not significant. **, ****: significant at the level of p<0.01 and p<0.0001, respectively.

Figure 7. The Chroma values in terms of treatments



Different letters on the bars indicate significant variance (ANOVA, p<0.05). ns: not significant. **: significant at the level of p<0.01.

Figure 8. The Hue° angle values according to treatments and colors

The color depends on many factors such as the variety of the grape, the extraction technique and the stabilization procedures applied [11]. It is known that UV-C causes degradation in color pigments [13]. Although UV-C treatment reduces the total monomeric anthocyanin content relatively, this effect was reported to be not significant [22]. In the same study, color intensity and polymeric color did not change significantly with UV-C treatment. A significant increase in brightness and a decrease in a* and b * were noted in the UV-C treated star fruit (*Averrhoa carambola* L.) juice [4]. With the treatment of ultrasound (1, 3 and 5 minutes), the chromatic properties of the anthocyanins and phenolic compounds of the selected wines were preserved for all periods [8]. Similar results have also been reported by [7]. The results obtained in our study support the reports of previous researchers.

CONCLUSION

This study was conducted to investigate the effects of UV-C and ultrasound treatments on some basic quality criteria of grape juices in different colors. As a result of the study, the effects of the treatments changed according to different grape juice colors and mostly showed more stable properties than the control. The fact that there is no serious decrease in the quality criteria due to the treatments and the knowledge of the effect of these treatments on reducing microbial activity in grape juice made valid reasons to try the treatments on different quality criteria for longer periods. Although these treatments have recently been tried on grape juice, studies are still very insufficient. Further researches will focus on the effects of UV-C and ultrasound treatments on other important properties (phenolic substances, organic acids, etc.).

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