International Journal of Agricultural and Natural Sciences
Uluslararası Tarım ve Doğa Bilimleri Dergisi
E-ISSN: 2651-3617 1(1): 39-44, 2018

The Effects of Ultrasound Treatments with Hot Water on Postharvest Quality of Fresh-Cut Green Onion

M.Ufuk KASIM[1] Rezzan KASIM[1*]
[1]Kocaeli University, Vocational School of Arslanbey, 41285, Kartepe-Kocaeli

*Corresponding Author
E-mail:rkasim@kocaeli.edu.tr

Abstract
The fresh onion, which has a short life after harvest, comes to the forefront with its nutritious and appetizing properties. Especially yellowing in the green parts and the elongation of white axle with dulling is known as a significant post-harvest losses of green onion. The aim of this study is to determine the effect of ultrasound treatment at different temperatures on post-harvest quality of onions. In the study, onions were harvested and then cleaned, sorted, washed and cut into two halves. After this, 52 dB ultrasound for fifteen minutes was applied to fresh-cut onions in the ultrasonic bath containing water at 35°C, 40°C and 45°C temperature. Onions that have not been treated with ultrasound are used as controls. After the applications, the onions were dried and placed into the polystyrene foam dishes as it will be 200 g onion in each dish which is then wrapped with polyethylene stretch film. After packaging, the onions were stored in cold room at a temperature of 4 ± 1 ° C and relative humidity of 85-90%. At the beginning of the experiment and at intervals of 5 days; color (*L*, a*, b**), total soluble solids (%), chlorophyll (SPAD), axle length (mm), axle diameter (mm) and weight loss measurements were performed in white and green areas. According to the results of this study, while 45°C temperature treatment decreased weight loss and increased brightness in white part, it accelerated chlorophyll breakdown. It is suggests to continue similar studies because of the positive effect of temperature application on the white part of onion.

Keywords: Green onion, Ultrasound, Hot water, Postharvest, Quality

INTRODUCTION

The green onion (*Allium cepa* L.) is a plant belonging to the family of the Alliaceae, and is a highly perishable vegetable due to its high moisture content and metabolic rate and also deficient postharvest management and transport conditions [1]. Onions are frequently eaten raw in salads, salsas and dips, and whole green onions can also be grilled or served raw on a relish tray. It is great source of vitamin A, C and K, manganese, potassium and copper minerals, and also, onion's fiber content is high and also they have low calorie [2].

Minimally processed fresh produce is one of the fastest growing segments of the food industry due to consumer demand for fresh, healthy, and convenient foods. However, mechanical operations of cutting and peeling induce the liberation of cellular contents at the site of wounding that can promote the growth of pathogenic and spoilage microorganisms. In addition, rates of tissue senescence can be enhanced resulting in reduced storage life of fresh-cut fruits and vegetables [3].

Increasing public demands for improved safety and quality of fruits and vegetables in the fresh market, awaken a growing interest for novel technologies for the preservation of postharvest fruits and vegetables before storage. Ultrasound technology provides one of the methods that with better treating time, enhanced products quality, reduced chemical hazards, low consumption of energy, and is environmentally friendly [4].

Ultrasound (ultrasonic) is one of the newest non-thermal methods to extend shelf life of fresh fruits and vegetables during storage. When compared with other novel techniques, ultrasound technology is perceived to be safer, non-toxic, and environmentally friendly; it is assumed to be benign by the public because it is used in hospitals for diagnostic imaging purposes [5]. Ultrasound technology is a form of vibrational energy in the frequency range of 20–100 kHz, which is beyond the threshold of human hearing [6] In the food industry, small amplitude sound waves are used to conduct non-destructive analyses and access physicochemical properties of food materials such as their composition, viscosity and structure [7].

Bal (2013) [5] studied that the effectiveness of putrescine (Put) (1 and 2 mM for 10 min) and ultrasound treatments (32 kHz for 10 min) alone or in combination on changing biochemical compounds and extending postharvest life of peach. The author was declared that individual and combined effects of putrescine and ultrasonic treatment, when compared to control fruits, could increase peach fruit postharvest life by inducing resistance to different diseases and chilling injury. At the same time, a combined putrescine and ultrasound treatment was found to be more effective than other treatments in decreasing respiration rate and maintaining firmness and acidity. Similar research was done with grape, and it was determined that combination treatments maintained higher levels of anthocyanins, total phenolic content, antioxidant capacity and reduced the loss of sensory acceptability and decay incidence compared to control [8].

In three different power densities ultrasound (66.64, 106.19 and 145.74 W/L) treated to tomato at 25°C temperature to determine the storage properties of tomatoes. Among the three levels of ultrasound irradiation, 106.19 W/L ultrasound was effective in reducing the spoilage microorganisms, delaying postharvest ripening through inhibiting ethylene production and respiration rates, and consequently maintaining fruit firmness, flavor, enzyme activities, antioxidants (total phenolics, total flavonoids), and the total antioxidant capacity of cherry tomatoes [9].

When CaCl2 and ultrasound together with applied to Santa Rosa plum variety, fruit firmness, fenolic substances and decay fruit rate was positively affected while fruit quality maintained better that the other treatments during 40 days of storage at 0-1°C temperature and 90-95% RH [10].

The aim of this study is; to determine the effect of ultrasound treatment at different temperatures on postharvest quality of fresh-cut green onions.

MATERIAL AND METHODS

Plant Material

Green onions (*Allium cepa* L.) were grown in Arslanbey Vocational School of Kocaeli University under usual production practices. Onions were harvested and then cleaned, sorted, washed and cut into two halves.

Ultrasound Treatments

52 dB ultrasound for fifteen minutes was applied to fresh-cut onions in the ultrasonic bath containing water at 35°C, 40°C and 45°C temperature. The samples without any application were using as a control (K); and the fresh-cut green onions immersed in water, were evaluating as water control (SK).

Packaging and storage

Ultrasound treated onions were dried and placed into the polystyrene foam dishes as it will be 200 g onion in each dish which is then wrapped with polyethylene stretch film. The packaged onions were stored in cold room at a temperature of 4 ± 1 ° C and relative humidity of 85-90%.

Chlorophyll SPAD Measurement

A SPAD chlorophyll meter (Minolta Camera Co., Osaka, Japan) was used to estimate the chlorophyll content of green leaf part of fresh-cut onion. For this purpose, 10 leaves were used in each treatment and SPAD readings [11].

Color Measurements

Color of the fresh-cut onions was measured with a chromameter Minolta CR-300 (Minolta, Osaka, Japan), equipped with an 8-mm measuring head and a D65 illuminant. The calibration of the meter was done manufacturer's Standard white plate. Color changes were quantified in the L*, a* and b* color space. Hue angle (ho = tan-1 (b*/a*) when a*>0 and b*>0 or ho= 180o+tan^{-1} (b*/a*) when a*<0 and b>0) was calculated from the a* and b* values. The color of fresh-cut onions was determined both a lower white leaf sheath and the green leaf part of fresh-cut green onion [12].

Stem diameter (cm)

Stem diameter of fresh-cut onion was measured on five onion stem, using caliper as cm.

Total Soluble Solids (TSS)

The total soluble solids (TSS) of fresh-cut green onion samples were determined in both white sheath and green leaf part for each treatment in three replications using an Atago DR-A1 digital refractometer (Atago Co. Ltd, Japan) at 20°C, and expressed as percent value (%) [11].

Weight loss (%)

The weight measurements were performed using three packages of each treatment group, both at the beginning and five days intervals during storage duration. The weight loss was calculated as percentage according to the following equation; WL (%)=(IW-FW/IW) 3 100, where WL is the weight loss, IW is the initial weight of samples, and FW is the final weight of onions.

Statistical Analysis

Experiments were carried out in a completely randomized design with a minimum of three replications per storage treatment per sampling date. Data were analyzed by SPSS and differences among means were determined by using Duncan's multiple range test with the significance level at p<.05.

RESULTS AND DISCUSSION

Chlorophyll SPAD

Chlorophyll content (SPAD) of green-onion decreased in all treatments, during storage (Fig. 1). But, the highest decreasing is found to be in samples treated with 45°C ultrasound (US) and followed by 35° US and 40°C US treatments. The lowest decreasing was obtained by control and water control treatments. Also differences between 45°C US treated samples and control is found to be significant, statistically. In addition the differences among the storage times were important statistically at the level of p<0.05.L* values of white sheat part of onion. Both ultrasound treatments and water control caused decreasing in chlorophyll content of fresh-cut green onion compared to control group. It was said that loosing green pigmentation accompanied by the predominance of yellow pigments is a natural process in the senescence of many vegetables, and such changes can be accelerated by ethylene. Also, it was declared that a stress to plant tissues increases ethylene production and respiration rate and thereby increases yellow pigments [13]. So, it can be said that the water and ultrasound caused a stress on fresh-cut green onion were accelerated metabolic activity of fresh-cut onions.

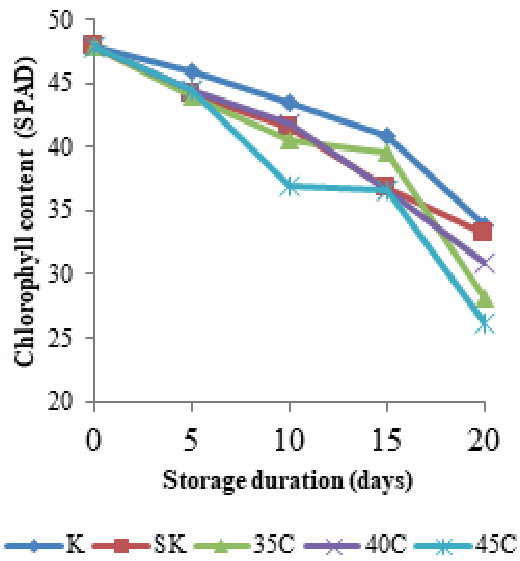

Figure 1. The change of chlorophyll SPAD values of fresh-cut green onion treated with different temperature ultrasound. (K: Control, SK: Water control, 35C: 35°C ultrasound, 40C: 40°C ultrasound and 45C: 45°C ultrasound).

L* values of fresh-cut green onion

As shown in Fig. 2, *L** values of fresh-cut green onion both green and white part increased, in all applications, during storage. But, the highest increasing is obtained by in 45°C treated samples, whereas it is the lowest in control group of green part of onions. The highest increasing is found to be in water control and in 45°C ultrasound treatments in white sheat of onions. *L** values of fresh-cut onions both white leaf sheath and green leaf increased in all treatments, but the lowest *L** values determined in control group. Therefore, it is found that the ultrasound treatments were increased *L** values by causing decrease in chlorophyll content, as seen in chlorophyll SPAD values. *L** value is represented brightness, whiteness or darkness of the samples [14]. While, higher L* values indicated whitening, lower *L** values showed darkness of samples.Therefore it was concluded that ultrasound treatments and water control incresad brightness of onions.

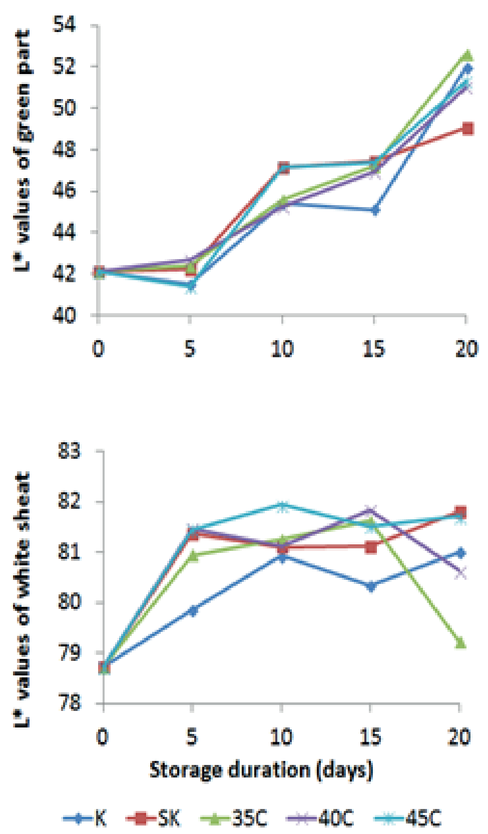

Figure 2. The change of L^* values of fresh-cut green onion treated with different temperature ultrasound.

(K: Control, SK: Water control, 35C: 35°C ultrasound, 40C: 40°C ultrasound and 45C: 45°C ultrasound).

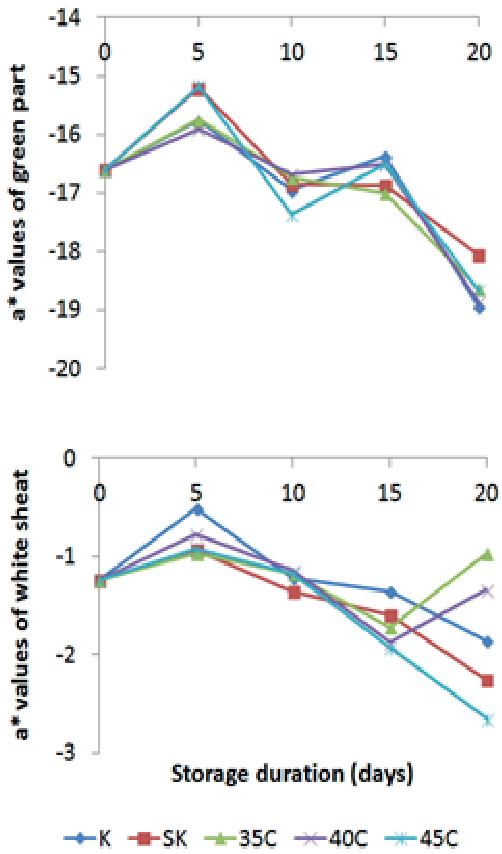

Figure 3. The change of a^* values of fresh-cut green onion treated with different temperature ultrasound. (K: Control, SK: Water control, 35C: 35°C ultrasound, 40C: 40°C ultrasound and 45C: 45°C ultrasound).

a* values of fresh-cut green onion

The a^* values of fresh-cut green onion increased for the first five days, both green and white part of onions (Fig. 3). Then it changed decreasing-increasing-decreasing in green part during storage. The differences among the treatments, however, were found insignificant at the level of $p<0.05$.But, it decreased except 35°C ultrasound and 45°C ultrasound treatment in white sheat part of onions. However, there were no significant differences found among the treatments.

b* values of white sheat of fresh-cut onion

b^* values of both green leaf part and white sheath of green onion was shown in Fig. 4. According to Fig. 4, b^* values in green leaf part of onion showed a slight decrease tendency in the first five days, with it generally increased during storage. The highest increasing was obtained by control and water control groups while, the lowest increasing was found in samples treated with 35°C ultrasound, and also the differences between these two treatment was determined significant statistically. The similar results also were obtained for white leaf part of onions.

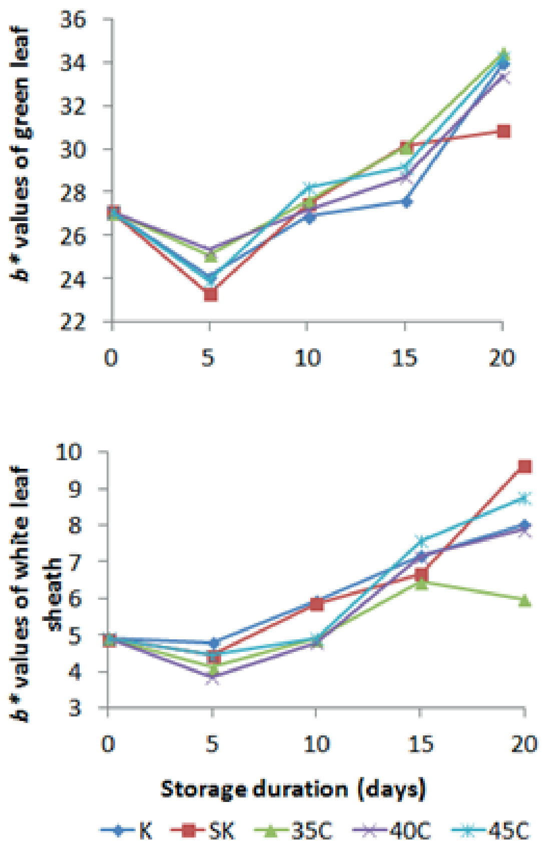

Figure 4. The change of *b** values of fresh-cut green onion treated with different temperature ultrasound. (K: Control, SK: Water control, 35C: 35°C ultrasound, 40C: 40°C ultrasound and 45C: 45°C ultrasound).

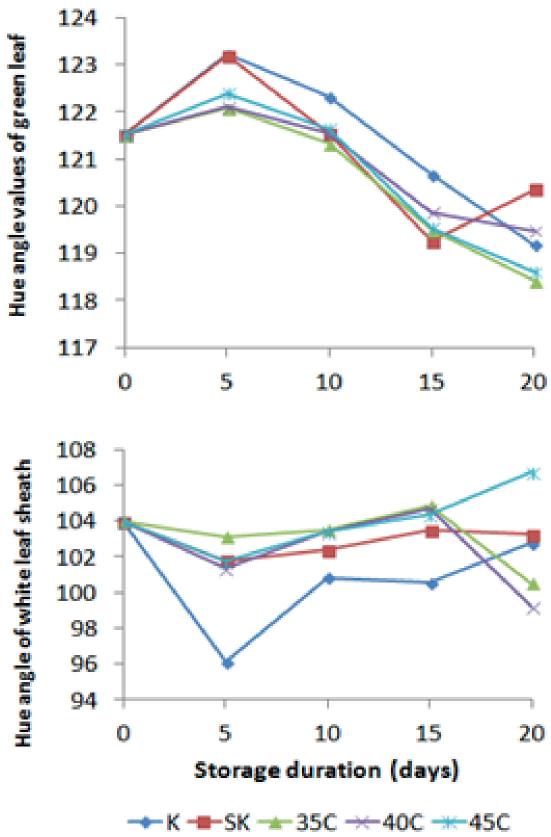

Figure 5. The change of hue angle values of fresh-cut green onion treated with different temperature ultrasound. (K: Control, SK: Water control, 35C: 35°C ultrasound, 40C: 40°C ultrasound and 45C: 45°C ultrasound).

Hue angle values of fresh-cut green onion

As seen in Fig.5, hue angle (HA) values of green leaf of onions rised for the first five days, however, they decreased during storage in all treatments. The highest decreasing was found in 35°C US treated onions compared with control. Also, the differences between these two group were found significant statistically. For the first five days, similar changes in HA values were obtained for white leaf part but the there was sharp decrease in control group, differently. After that, HA values of onion in all treatment groups increased. But the differences among the treatment were not found significant statistically. Color is one of the main attributes, along with texture, that characterizes the freshness of most vegetables. Also, it was declared that the hue angle values refer true color of crops [15]. In the present study it was found that the hue angle values of green leaf part of fresh-cut onions decreased during storage, and the US treatments had played effective role this decrease. Furthermore, changes in hue angle values were found correlated with chlorophyll SPAD values.

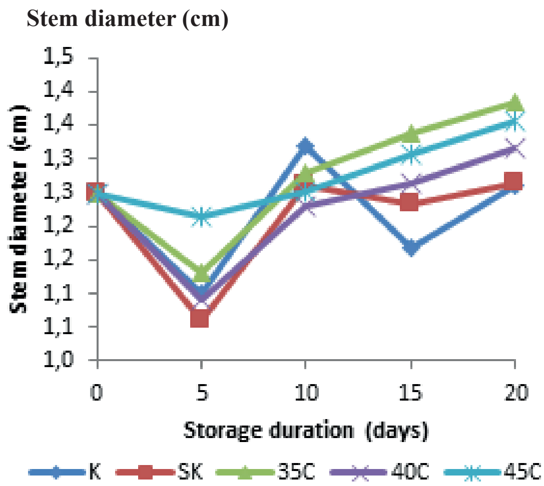

Figure 6. The change of stem diameter values of fresh-cut green onion treated with different temperature ultrasound. (K: Control, SK: Water control, 35C: 35°C ultrasound, 40C: 40°C ultrasound and 45C: 45°C ultrasound).

Stem diameter of fresh-cut green onion decreased except 45°C ultrasound treatment for the five days of storage, after these it changed as increasing-decreasing in control and water control treatments, whereas it increased in all ultrasound treatments (Fig. 6). Also, the highest increasing was calculated by 35°C ultrasound treatment, it was followed by 45°C and 40°C ultrasound treatments. The differences among the treatments, however, were not found significant statistically. In this study, stem diameter (cm) of fresh-cut green onion samples is protected by 45°C US treatment, so it can be said that this treatment was positive effect on stem diameter than the other treatments.

Total soluble solid of fresh-cut green onions

TSS values of green part of fresh-cut onion lower than white sheat part, and while it changed in the range of 8.53-10.07 in white part, 2.98-7.07 the in green part of onions (Fig. 7). TSS content of green part of onion increased in "water-control", 35°C US and 45°C US until the end of the storage, whereas it increased in control and 40°C US treatments for first two week. The differences among treatments, however, did not found significant, statistically. The highest TSS of white sheat of fresh-cut onion was determined in 40°C US treatment, and was followed by control, water control, 35°C US and 45°C US treatments for the first tens days storage. After these, while it decreased in all US treatments, inreased in control and water control treatment until the end of storage duration. But, the differences among the treatments were found insignificant, at the level of $p<0.05$. In the present work, it was determined that the TSS values of white leaf base higher than green leaf part of fresh-cut onions. Also, the 40°C US treatment was effective to increasing the TSS of onions compared to other treatments.

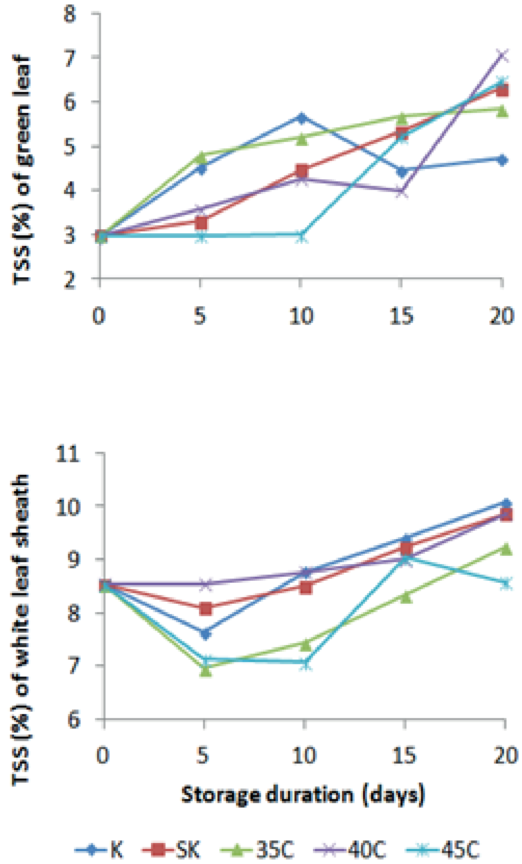

Figure 7. The change of TSS values of fresh-cut green onion treated with different temperature ultrasound. (K: Control, SK: Water control, 35C: 35°C ultrasound, 40C: 40°C ultrasound and 45C: 45°C ultrasound).

Weight Losses

Weight loss of fresh-cut green onions increased in all treatments, during the storage. The highest weight loss was measured in control treatment it followed by 40°C US, 35°C US, water control and 45°C US treatments, respectively. While the weight loss was changed 6.65-8.52% in the tenth days of storage, it getting increase after that time and reached 15.48-18.65% at the end of the storage. In this study, it was concluded that, the US treatments were controlled weight loss of fresh cut green onions compared with control group. Also, the lowest weight loss was measured in 45°C US treatment.

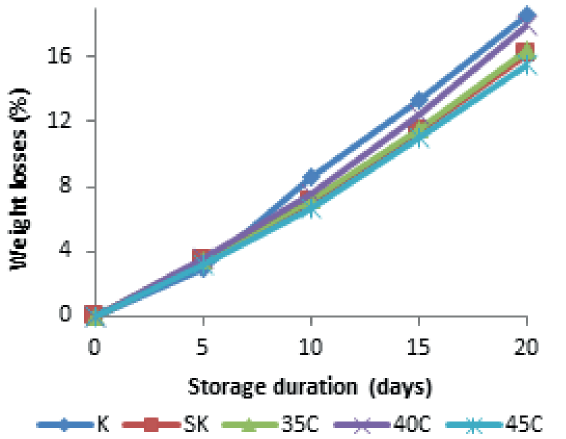

Figure 8. The change of weight loss values of fresh-cut green onion treated with different temperature ultrasound. (K: Control, SK: Water control, 35C: 35°C ultrasound, 40C: 40°C ultrasound and 45C: 45°C ultrasound).

CONCLUSION

In the present work, the effect of ultrasound and hot water combination on postharvest quality of fresh-cut green onions was studied. According to the results, it was found that the 40°C and 45°C US treatments succesfull for higher TSS and lower weight loss, and also the brightness of fresh-cut onions increased by US treatments. But generally, ultrasound treatments caused fading of green color. So, it can be said that the hot water and ultrasound caused increasing metabolic activity of fresh-cut green onion, therefore the new studies should be done to determine different ultrasound treatments to protect quality of fresh-cut products

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