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Potential of rosemary leaves and branches to enhance storage life of onion bulbs

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ABSTRACT

Although its importance as vegetable, a considerable amount of onion bulbs is lost in storage. That's why storage condition is one of the most important issues to maintain post-harvest quality. For this purpose, a factorial experiment based on randomized complete block design with two factors and three replicates was carried out. The factors were storage conditions of onion bulbs with five levels (4°C in the seed storage apparatus, 25 and 30°C without using rosemary leaves and branches in the incubator, and 25 and 30°C using rosemary leaves and branches in the incubator) and storage times with ten levels (10 consecutive weeks). The storage feedbacks of bulbs in terms of the weight loss (WL) and the average bud length (ABL) of bulbs were analyzed. The storage of bulbs at 25°C using rosemary fresh leaves and branches inside each bag of bulbs after 10 weeks resulted in the lowest weight loss and average bud length, and significantly controlled the post-harvest fungal rotting and improved the shelf life of bulbs. The findings of this study indicated the high potential of rosemary fresh leaves and branches, which can be considered as an alternative strategy to control post-harvest fungal rotting and to improve the storage life of bulbs considering its simplicity and efficacy in decreasing the storage cost, the weight loss and sprouting without causing any environmental toxicity.

Keywords: *Allium cepa*, *Rosmarinus officinalis*, temperature, sprouting, storage life.

RESUMO

Potencial de folhas e ramos de alecrim para melhorar o tempo de armazenamento de bulbos de cebola

Apesar de sua importância como vegetal, uma quantidade considerável de bulbos de cebola é perdida durante o armazenamento. Portanto, as condições de armazenamento tornam-se uma das questões mais importantes visando manter a qualidade pós-colheita. Com esta finalidade, instalou-se um experimento fatorial em delineamento de blocos ao acaso, com dois fatores e três repetições. Os fatores foram constituídos pelas condições de armazenamento com cinco níveis (4°C no aparelho de armazenamento de sementes, 25 e 30°C sem o uso de folhas e ramos de alecrim na incubadora, e 25 e 30°C, utilizando folhas e ramos de alecrim na incubadora) e tempos de armazenamento com dez níveis (10 semanas consecutivas). Foram analisados os armazenamentos de bulbos em termos de perda de peso e comprimento médio do seu broto. O armazenamento dos bulbos a 25°C, com o uso de folhas e ramos frescos de alecrim dentro de cada saco de bulbos após 10 semanas, resultou na menor perda de peso e comprimento médio do broto com controle significativo de fungos pós-colheita, melhorando o tempo de armazenamento da cebola. Os resultados deste estudo indicam o elevado potencial de folhas e ramos frescos de alecrim, que podem ser considerados uma estratégia alternativa no controle de fungos pós-colheita com consequente melhoria da vida de armazenamento da cebola, considerando sua simplicidade e eficácia na diminuição do custo de armazenamento, a menor perda de peso e menor brotação, sem causar qualquer toxicidade ao ambiente.

Palavras-chave: *Allium cepa*, *Rosmarinus officinalis*, temperatura, brotação, vida de prateleira.

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In terms of storage loss, onion (*Allium cepa*) is situated as the second vegetable, after tomato (Briggs & Goldman, 2002). Onion bulbs stored for long periods are subjected to storage rot, sprouting, rooting, and loss of water making dehydration necessary as a method of preservation (Akbari & Patel, 2003). The loss prevention and reducing methods are related to the production stages and post-harvest conditions.

Storage conditions play an important role in increasing the storage life and conservation of horticultural products (Nazir *et al.*, 2001). Although fruits and vegetables are often treated with fungicides to delay post-harvest disease but, due to the adverse effects of chemicals on human life and environmental pollution, the application of them is limited in the storage process (Sargent *et al.*, 2001; Unnikrishnan & Nath, 2000).

Environmental technologies can be used for storage of horticultural products to minimize losses (Nazir *et al.*, 2001; Sargent *et al*., 2001; Afek & Kays, 2004). Recently, non-chemical methods such as the use of gamma rays, UV light, heat therapy and the use of natural ingredients such as essential oils from plants such as rosemary have been developed in the storage process

of horticultural products (Nazir *et al.*, 2001; Sargent *et al.*, 2001; Afek & Kays, 2004; Khodadadi & Zolfagharyeh, 2009).

Rosemary (*Rosmarinus officinalis*) is a spice and medicinal herb widely used around the world. It is mainly produced in Italy, Dalmatia, Spain, Greece, Turkey, Egypt, France, Portugal and North Africa (Atti-Santos *et al.*, 2005). The essential oil of dried leaves of rosemary ranged from 0.5 to 1.5%. The rosemary leaves are used in foodstuffs, especially for the control of microbial infections (Lawrence, 2000; Rasooli *et al.*, 2008). The leaves are also reported to be an antioxidant due to the presence of rosmarinic acid, carnosol, carnosic acid and caffeic acid (Hraš *et al.*, 2000).

Of the natural antioxidants known, rosemary has been widely accepted as one of the spices with the highest antioxidant activity (Ramírez *et al.*, 2004; Peng *et al.*, 2005). The essential oil of rosemary has been reported to be a tonic stimulant and is used as a pulmonary antiseptic, a choleretic, a colagoguic, and also shows stomachic, antidiarrhoeal and antirheumatic properties (Pintore *et al.*, 2002).

Recently, the exploitation of natural products to control decay and prolong storage life of perishables has received more and more attention (Tripathi *et al.*, 2008). Rosemary has antimicrobial properties and can be important in reducing post-harvest losses of the frequency range of interest. It has also essential oils, is rich in bioactive compounds, and has antioxidative and antimicrobial properties. In addition, the use of essential oils have established increasing attention as the natural additives for the shelf-life extension of food products, due to the risk in using synthetic preservatives (Tongnuanchan & Benjakul, 2014).

Investigation on the mode of action and practical applicability of such plant products is required to recommend their formulation in control of post-harvest diseases (Tripathi *et al.*, 2008). Biologically active essential oils represent a rich potential source of an alternative and perhaps environmentally more acceptable disease management compounds. With a broad range of natural fungicidal plant volatiles, numerous opportunities exist to explore their usefulness in controlling post-harvest diseases. In the current study, we report how rosemary fresh leaves and branches enhance the storage life of onion bulbs.

MATERIAL AND METHODS

Plant material

Uniform sized and shaped red onion known as Azarshahr bulbs were provided from the Seed and Plant Improvement Institute, Karaj, Iran. Fresh leaves and branches of *Rosmarinus officinalis* were collected from the experimental field of Medicinal Plants Research Center, Shahed University, Tehran, Iran.

Experimental technique

The experiment was conducted in the Department of Horticulture, Agriculture Science Faculty, Shahed University, Tehran, Iran, during August to November 2012. We carried out a factorial experiment based on randomized complete block design (RCBD) with two factors and three replications. The studied factors were storage conditions with five levels {4°C in the seed storage apparatus, 25 and 30°C without using rosemary leaves and branches, and 25 and 30°C using rosemary leaves and branches in the controlled incubator (dark regime and relative humidity 65-70%) and ten storage times (1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 weeks)}.

Five hundred grams of red onion bulbs, of same size and shape, were placed into each bag (totaling 15 bags), separately. The three bags of onion samples (control samples) were located in the seed storage apparatus at 4°C, three bags in the incubator at 25°C and three bags in the incubator at 30°C, separately. One hundred and twenty grams of fresh leaves and branches of rosemary were put inside each bag (totaling six bags) between the onion bulbs. The three bags were located in controlled incubator at 25 and three bags at 30°C, separately. After one week, the weight loss (WL) and the average bud length (ABL) of bulbs were measured every week during 10 weeks of experimental period.

Statistical analyses

The SPSS software version 22 was used for all statistical analyses including the raw data normality test and the main data analysis as well as for the Duncan's multiple range test ($P \leq 0.01$). The graph pad prism software No. 5 was used for drawing the graphs.

RESULTS AND DISCUSSION

The analysis of variance showed that different storage conditions (SC) and storage times (ST) affected the weight loss (WL) and the average bud length (ABL) of onion. Variation due to storage conditions, storage times and their interaction was highly significant ($P \leq 0.01$). The interaction of SC × ST was significant in terms of the weight loss (WL) and the average bud length (ABL). Both studied traits varied with SC and ST.

The highest WL and ABL (24.07 g and 2.87 cm) were observed after 10 weeks of storage time, whereas the lowest (0 g and 0 cm) with the same condition happened after one week (Figure 1). Onions started to lose weight on the second week of storage and, bud growth started on the sixth week. The results indicated that there were high significant difference among storage times on WL and ABL of onion. The mean WL over the storage conditions varied from 6.63 g at 4°C (control) to 21.27 g at 25°C without using rosemary leaves and branches (Figure 2). Among the storage conditions, 25°C with use of rosemary leaves and branches gave the lowest decrease of WL (6.63 g) followed by 30°C with use of rosemary, 30 and 25°C without using rosemary, respectively. Whereas among the storage conditions, 30°C with using rosemary gave the lowest ABL (0.64 cm) followed by 25°C with using rosemary, 25 and 30°C without using rosemary, respectively. Overall, 25°C with using rosemary leaves and branches and 30°C with using rosemary leaves and branches were the best conditions with respect to WL and ABL (Figure 2).

The slope of the weight loss showed

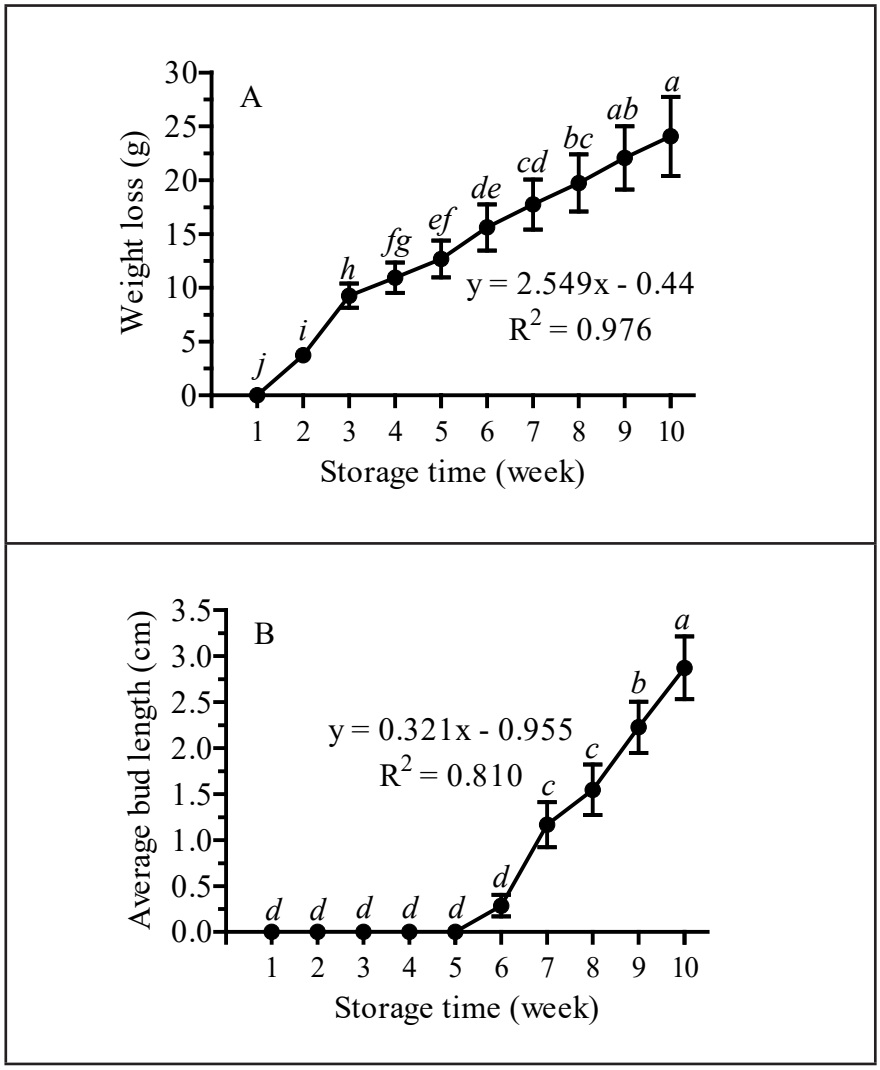

Figure 1. Effects of storage times on the weight loss (a) and the average bud length (b) of onion bulbs using Duncan's multiple range test (P≤0.01). Different letters indicate significant difference between the values of pair of treatments. Vertical bars represent standard error of mean for three samples {efeito dos tempos de armazenamento sobre perda de peso (a) e comprimento médio do broto (b) de bulbos de cebola pelo teste de Duncan (P≤0.01). Letras diferentes indicam diferença significativa entre pares de tratamentos. Barras verticais representam erro padrão da média para tres amostras}. Tehran (Iran), Agriculture Science Faculty, 2012.

2.549 g decrease per storage time (one week), and the slope of the average bud length showed 0.321 cm increase per storage time (one week) (Figure 2). This might be due to the effect of storage time. As shown in Figure 3, after 10 weeks the greatest and lowest decrease in WL was observed at 25°C without using rosemary leaves and branches and 25°C with using rosemary leaves and branches, respectively. Interestingly, the amount of decrease in 25°C with using rosemary leaves and branches condition was lower than normal storage condition (4°C) (Figure 3). In addition, application of rosemary leaves and branches at 25 and 30°C significantly decreased the ABL after 10 weeks of storage time (Figure 3).

Temperature is one of the most important factors in maintaining the post-harvest quality. Weight loss and sprouting of onions are common responses to storage times and storage conditions. Considering the high percentage of weight losses of onion bulbs in the storage (about 25%), measures should be taken in this regard. In order to investigate the storage life of bulbs, a set of critical post-harvest-related indices such as weight loss and sprouting of onions were evaluated under different storage conditions and storage times. All the studied post-harvest-related indices were affected under different storage conditions and storage times.

Refrigerated storage to control the respiration rate of crops, delays the following elements of deterioration, including aging due to ripening, softening, color change, undesirable metabolic changes, respiratory heat production, moisture loss and the wilting that results spoilage due to invasion by bacteria, fungi, and yeasts (Hardenburg *et al.*, 1990). The storability of onion bulbs is dependent on the rate of internal sprout growth which is controlled, in part, by endogenous hormones (Chope *et al.*, 2006).

Respiration generates heat from oxidized sugars, fats, and proteins in the cells of the crop. The loss of these stored food reserves through respiration leads to reduction in food value, loss of flavor, loss of marketable weight, and more rapid deterioration. The respiration rate of a product strongly determines its transit and post-harvest life (Wilson *et al.*, 1995). Standard methods of suppressing sprouting in temperate climates include controlled atmosphere, ambient or cold storage with/without controlled relative humidity in addition to the pre-harvest application of maleic hydrazide (Johnson, 2006).

Application of gamma radiation is a common methods for decreasing the weight loss and enhance the percentage of marketable bulbs (Curzio & Croci, 1983), which has high cost and environmental toxicity, while application of some natural products such as flavor compounds, acetic acid, jasmonates, glucosinolates, propolis, fusapyrone and deoxyfusapyrone, chitosan and essential oils for the management of fungal rotting of fruit and vegetables has been developed to minimize the environmental toxicity and storage cost (Tripathi *et al.*, 2008). Although the exploitation of natural products to protect the post-harvest decay of perishable products is in

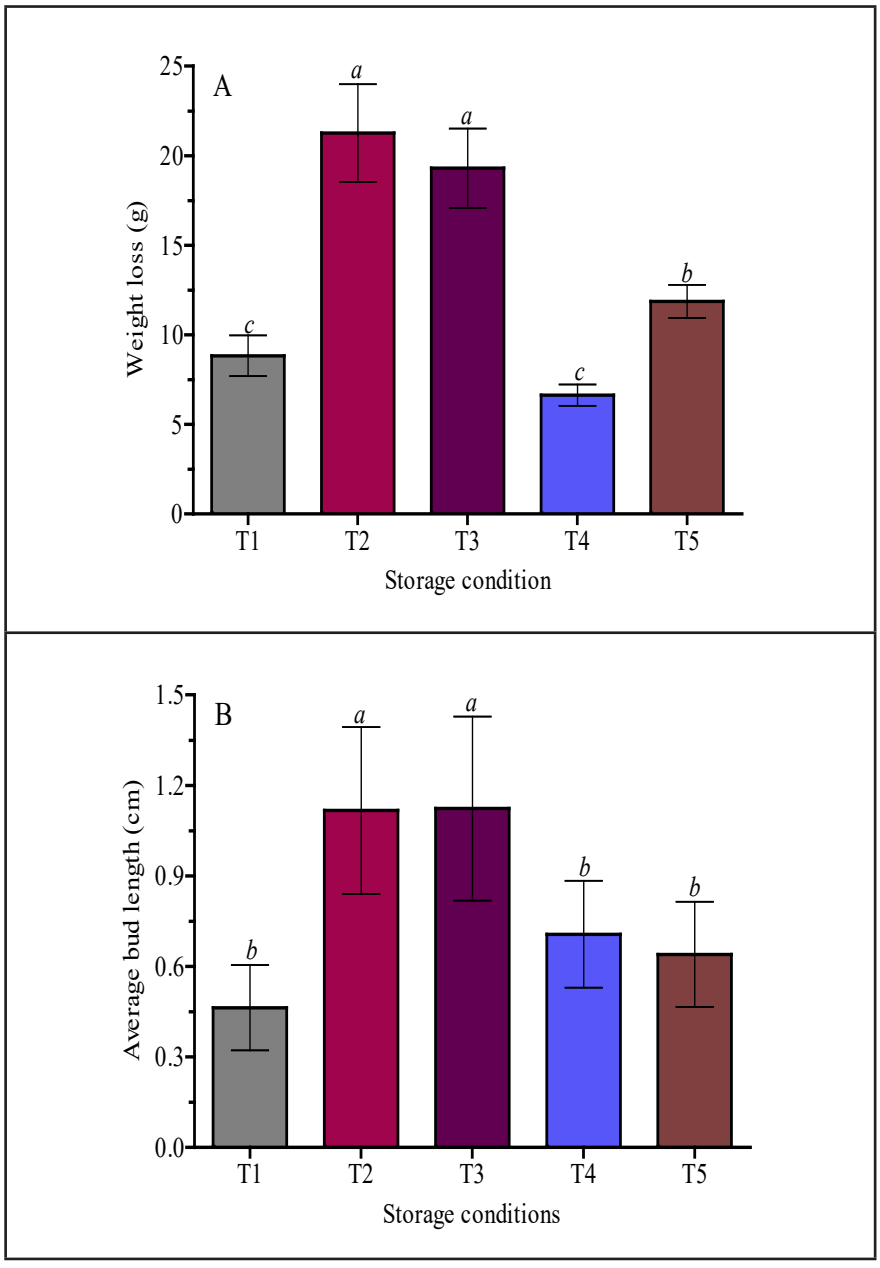

Figure 2. The effects of storage conditions on the weight loss (a) and the average bud length (b) of onion bulbs using Duncan's multiple range test (P≤0.01). Different letters indicate significant difference between the values of pair of treatments. Vertical bars represent standard error of mean for three samples. The storage conditions were T1= 4ºC in the seed storage apparatus; T2= 25ºC and T3= 30ºC without using rosemary leave and branches, T4= 25ºC and T5= 30ºC with using rosemary leave and branches in the controlled incubator {efeito das condições de armazenamento sobre perda de peso (a) e comprimento médio do broto (b) de cebola pelo teste de Duncan (P≤0.01). Letras diferentes indicam diferença significativa entre pares de tratamentos. Barras verticais representam erro padrão da média para tres amostras. As condições de armazenamento foram T1= 4ºC no aparelho de armazenamento de sementes; T2= 25ºC e T3= 30ºC sem o uso de folhas e ramos de alecrim; T4= 25ºC e T5= 30ºC utilizando folhas e ramos de alecrim}. Tehran (Iran), Agriculture Science Faculty, 2012.

its infancy, these products have the potential to be safe fungicides and will replace the synthetic ones (Tripathi *et al.*, 2008). Our results revealed the importance of rosemary leaves and branches to control post-harvest fungal rotting and to improve the storage times and decrease the weight loss.

Tripathi *et al*. (2008), in a study on the essential oils of the ten plants viz. *Chenopodium ambrosioides*, *Eucalyptus citriodora, Eupatorium cannabinum, Lawsonia inermis*, *Ocimum canum*, *O. gratissimum, O. sanctum, Prunus persica, Zingiber cassumunar and Z. officinale*, recommended that the essential oils could be as a potential source of ecofriendly botanical fungicide, after long term and wide ranging trials to exhibit absolute fungitoxic activity up to 100% growth inhibition. Applying the rosemary leaves and branches to reduce germination and onion weight, the fungal infection and decay is most effective approach than recommended chemicals or irradiation storage in onion bulbs. Our results indicated that germination rate of all treatments except the rosemary treatment at temperatures above 4ºC increased. Variation due to storage conditions was significant in terms of germination rate, average bud length; number of active buds and tuber weight. In agreement with the reports of Struik & Wiersema, (1999) and Van-Ittersum & Scholte (1992), the findings of this research indicated that high temperature decreased the storage time and increased the weight loss and the average length of sprouts, while high temperature with applying rosemary leaves and branches increased storage time and the weight loss and sprouting of onion bulbs were the lowest.

Our results revealed that the onion bulbs had no sprouting during the first five weeks but by increasing storage time onion started to sprout and therefore the average bud length increased, which matched up with findings of Hartmans & van-Loon (1987) who reported that with increasing storage temperature, the average bud length and number of sprouts of potato tubers increased.

The use of herbal ingredients and essential oil to the proper sensory tests are needed before any recommendations. Maintaining the benefits of the plant as fungi toxicants effective post-harvest during the laboratory tests should be applied properly to the power of the test based on *vivo* experiments, tests and safety features much sense (Tripathi & Dubey, 2004). In order to make better use of the rosemary and other herbs in post-harvest storage of horticultural

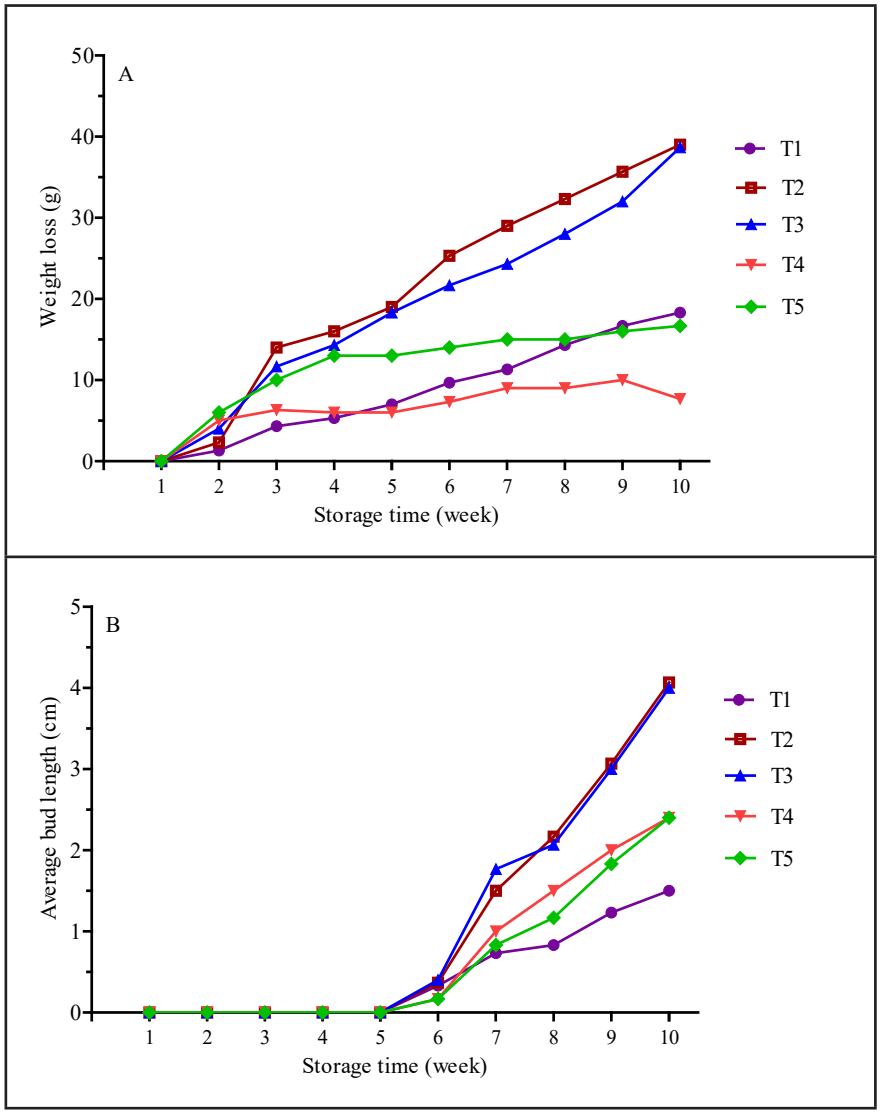

Figure 3. Interaction effect of storage times and storage conditions on the weight loss (a) and the average bud length (b) of onion bulbs. Applying the Rosemary leaves and branches at 25°C storage conditions showed lowest weight loss and the average bud length {efeito da interação entre tempos de armazenamento e perda de peso (a) e comprimento médio do broto (b) de bulbos de cebola. Armazenamento de folhas e ramos de alecrim a 25°C apresentou a menor perda de peso e menor comprimento médio do broto}. Tehran (Iran), Agriculture Science Faculty, 2012.

crops, the investigation of other forms of application is recommended, such as the use of essential oil or foliar spray application on quality parameters such as taste and flavor of fruits and vegetables.

As a final conclusion, considering weight loss and sprouting (the average bud length) traits related to shelf life, the application of rosemary fresh leaves and branches can be considered as an alternative strategy to control post-harvest fungal rotting to improve the storage life of onions. This method is simple and effective in decreasing the storage cost, the weight loss and sprouting without causing any environmental toxicity. Therefore, the research can be tested on other post-harvest fruits and vegetables to improve the storage life.

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