Refrigeration Needs for Sustainable Preservation of Horticultural Products

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Abstract: Fresh horticultural products are highly perishable and need refrigeration for further preservation. Refrigeration needs energy consumption with consequent economical cost and damage for the environment. The objective of the present work was to use efficiently the refrigeration according to the product needs and time for consumption. *Salicornia ramosissima* and *Sarcocornia perennis* fresh branch tips, which are used for fresh salads, were stored at 1, 4 and 9 ºC for up to 21 days. In both species, fresh tips were of good consumer acceptability for up to 14 days at 9ºC. At 1 and 4 ºC fresh tips could be stored in good conditions up to 21 days. For efficient use of energy in refrigeration of fresh salicornia and sarcocornia we conclude that if it is to put those products in the market earlier we can use the higher temperature for storage saving energy. Only for further storage we shall use the lower temperatures.

Key-words: Food salads, halophytes, refrigeration, sustainability, postharvest technologies, energy efficiency, safe food.

1 Introduction

Food system in our days is built upon refrigeration. For many foods, refrigeration is a feature of almost every stage in the supply chain [6]. Fresh horticultural products are important components of human food. However, those products are highly perishable and losses can be of great importance if postharvest correct measures are not provided [2].

To ensure the highest and appropriate quality of horticultural products availability for consumers, it is very important that all parts involved in the chain from farm to plate (production, packaging, storage, transport, distribution and marketing) do everything correctly [8].

This means correct production, harvest and postharvest practices, so that we can have a high quality product which needs less energy consumption for keeping quality through the marketing chain.

Temperature is the most important factor in maintaining quality after harvest. Refrigeration is the first approach to increase storage life of fresh fruits and vegetables since it reduces respiration and other metabolic processes. Refrigerated storage retards deterioration in perishable crops such as, aging due to ripening, softening, and textural and colour changes; undesirable metabolic changes and respiratory heat production; moisture loss and the wilting that results; spoilage due to invasion by bacteria, fungi, and yeasts; undesirable growth, such as sprouting of potatoes [3].

However, lower temperature limits depend on product commodities since, for some, chilling injuries that damages product can occur above the freezing point [13].

Sustainable development has been defined as the development which meets the needs of the present without compromising the ability of future generations to gather their own needs [14], and integrates economic, social and environmental factors [2]. Sustainable agriculture is the one that produces enough food without depleting the earth's resources or polluting its environment. It is agriculture that follows the principles of nature to develop systems for raising crops and livestock that are, like nature, self-sustaining [5].

In postharvest, good management of energy saving in refrigeration is also through a good management of pre-cooling and cooling systems and storage rooms insulation. Also, while refrigeration entails the use of energy it can of course also help save energy by reducing food waste [6].

Usually, fresh horticultural products are stored at temperatures as lower as possible without causing chilling or freezing injury, to preserve them for as longer as possible with good acceptable quality. However, some produce is consumed earlier and some later through time after harvest, so refrigeration needs can be reduced accordingly. The reduction of energy consumption for refrigeration through the supply chain of fresh horticultural products, gives advantages as reducing costs and protecting the environment.

Halophytes are plants which tolerate or even demand sodium chloride concentrations in the soil water they absorb. Commercial use of halophytes as fresh food is not very common in our days, but due to recent global changes desertification enhances the need of irrigation with sub-saline water, which provokes the increase of soil salinization. At the same time, the need for renewable energy production from agricultural crops will extend this use to low quality soils and furthermore, limited fresh water resources may increase the use of low quality irrigation water. Hence, intensified use of salt tolerant crop plants will be necessary even in Europe. Several halophyte species are nowadays used as special crop plants.

The objective of the present research was to find which temperature to apply for storage of two halophytes (*Salicornia ramosissima* and *Sarcocornia perennis*) which grow naturally in the *Ria Formosa* salt marsh wetland in Algarve, Portugal and are used for fresh salads, according to the time needed in the chain from harvest to consumption. The knowledge on correct temperature for the appropriate storage period of those horticultural products will assist energy efficiency in pos-harvest and consequently sustainability.

2 Materials and methods

2.1 Plant material and treatments

Salicornia ramosissima and *Sarcocornia perennis* plants, which grow naturally in some salt marsh wetland of Algarve, Portugal were harvested in May-June and immediately transported to the Postharvest lab at the University of Algarve.

Tips of 6-8 cm youngest fully expanded branches were separated, washed and stored in polystyrene expanded trays, adequate for food storage, and covered with a 10 µm thick polyethylene film. Then, tips were stored in cold rooms at 1, 4 and 9 ºC for 21 days. At 0, 7, 14 and 21 days quality evaluation was performed for each replication (total of 3) and temperature treatment.

2.2 Measurements

Weight loss was calculated by weighting always the same samples and expressed as the percentage of the initial weight.

Colour was measured on kiwifruit slices with a Chroma meter CR-300 series (CE Minolta, Japan) and quantified in the CIE L*, a*, and b* colour space. The L* value indicates lightness (black=0 and white=100), a* changes from green (negative values) to red (positive values), and b* from blue (negative values) to yellow (positive values) [9].

2.3 Statistical analysis

Statistical analyses were carried out with a SPSS 16.0 computer program (SPSS Inc.). Two-way analyses of variance (ANOVA) tests at ($P<0.05$) for comparisons among treatments over time were conducted.

3 Results and discussion

3.1. Weight loss

Weight loss was reduced by temperature decrease in both species (Figs. 1A and B).

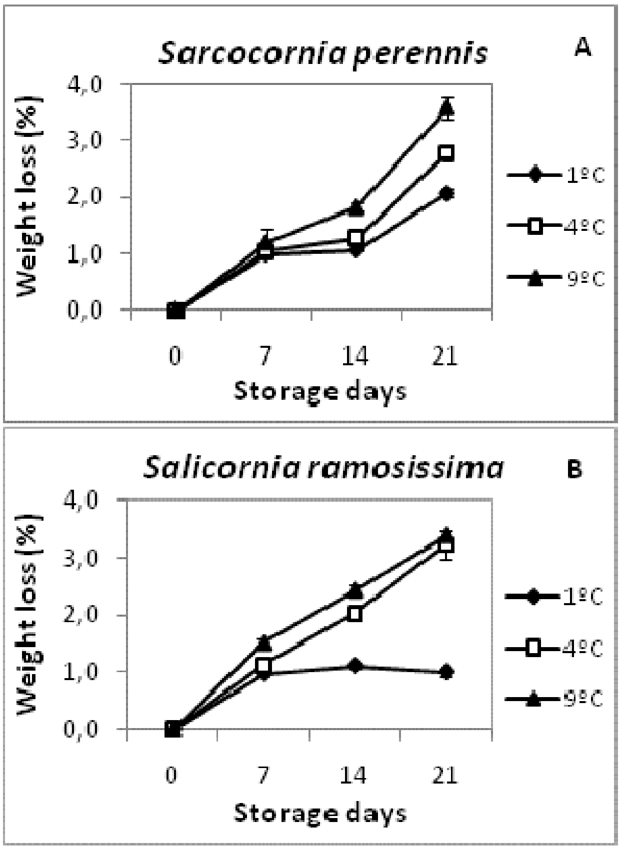

Figure 1. Weight loss of fresh branch tips of sarcocornia (**A**) and salicornia (**B**) stored for 21 days at 1, 4 and 9 ºC.

Weight loss is mostly dependent on the relative humidity surrounding the product, but can be also associated with a slight reduction in firmness [1, 7].

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Weight loss is of great importance because is associated to shrivelling and advance senescence, making the salad with a not fresh appearance.

In the case of the present work, the weight loss was not of significant importance till 14 days storage at 4 and 9ºC for salicornia and till 21 days for sarcocornia at 4ºC, since it did not reach 3%. Usually, horticultural products lose their fresh appearance when they have more than 3% weight loss [4].

The fact that the tips of both species were packed in modified atmosphere (MAP) helped to decrease the weight loss, since it is known to be efficient in reducing water loss by fresh horticultural products as well as respiration rate [11]. This fact helped to increase storage life capacity at a given temperature and in addition give protection against pathogen spoilage.

3.2. Colour

Colour did not have a significant change through 21 days at 1 and 4 ºC for sarcocornia (Figs. 2 A, B C).

Colour at 9 ºC, there is an increase in a* and b* values and a decrease in L* being significantly different from treatments at 1 and 4 ºC after 21 days storage.

The decrease in L* and the increase in a* indicates browning of the tissues [10, 12], as well as b* increase indicates yellowing [9], indicating loss of freshness. This means that sarcocornia at 9 ºC lost freshness mainly from 14 to 21 days.

Salicornia fresh tips followed the same patern as sarcocornia, but in this case differences in colour parameters after 21 days are higher (Figs. 3 A, B and C). This indicates a higher susceptibility of salicornia to deterioration than of sarcocornia.

4. Conclusions

Halophytes grow in saline habitats and are source of food, fibre and bioenergy. Halophytes help combat salinisation, soil erosion, loss of biodiversity and bioproductivity. Halophylic plants, Salicornia ssp. and sarcocornia are consumed today in Europe as fresh or cooked gourmet foods. Several studies with these species reported their high nutritional content, however, the supply of these plants is limited because of low knowledge on storage. As observed visually and from the data presented, either salicornia or sarcocornia showed a good acceptable quality for consumption up to 21 days at 1 and 4 ºC. At 9ºC such quality was achieved only till 14 days.

Horticultural products are highly perishable. Reduction of energy consumption for refrigeration in the chain from farm to consumption, enclose a good knowledge of the management of horticultural products. Preharvest adequate cultural practices are very important to give a quality product which keeps better in postharvest life. In addition, correct harvest measures provide reduction of postharvest losses.

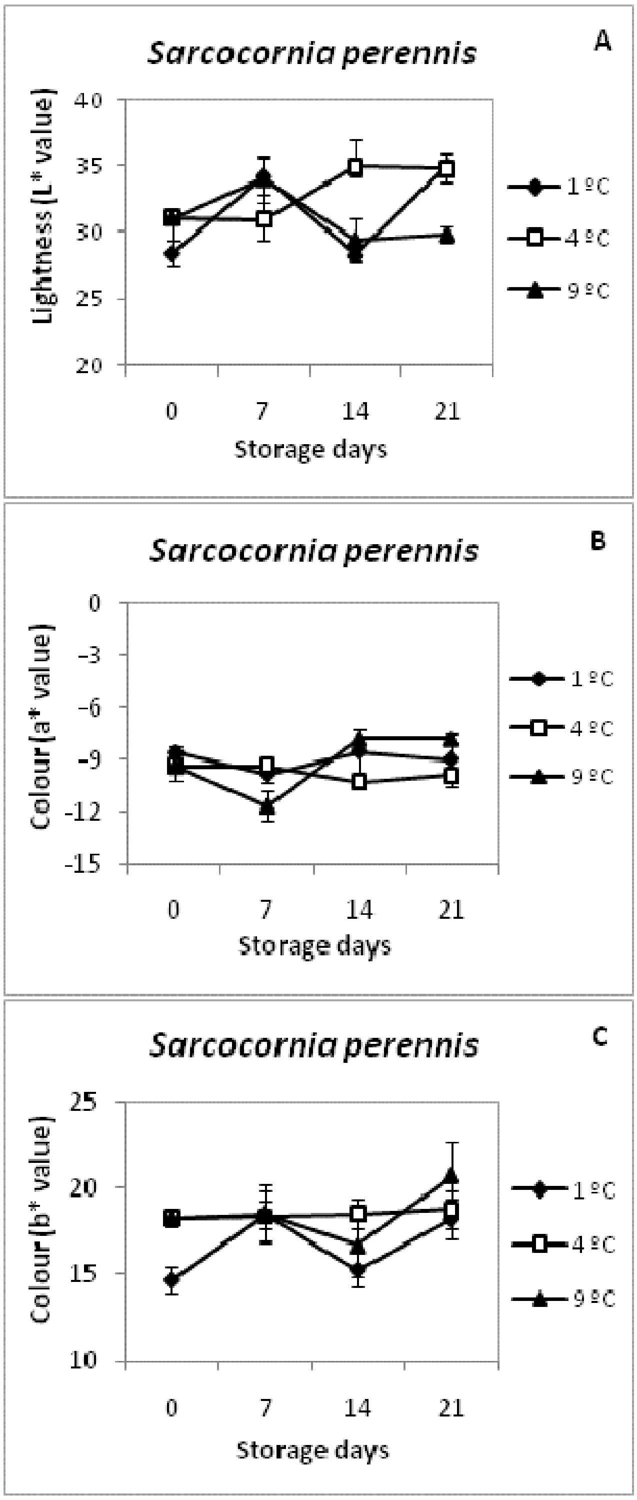

Figure 2. Colour parameters (L*, a* and b*) of fresh branch tips of sarcocornia stored for 21 days at 1, 4 and 9 ºC.

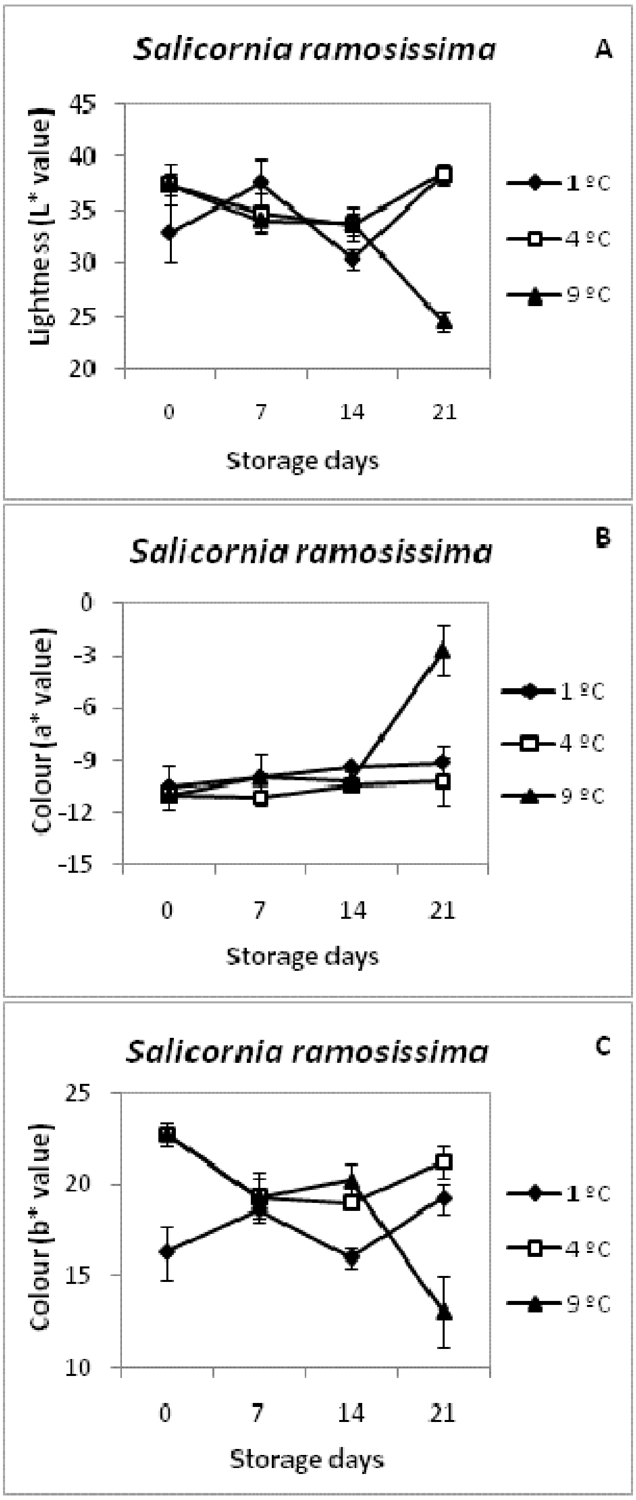

Figure 3. Colour parameters (L*, a* and b*) of fresh branch tips of salicornia stored for 21 days at 1, 4 and 9 ºC.

Those technologies as well as good management of energy in refrigeration through good insulation of storage rooms and good management of pre-cooling and cooling systems are of great importance for energy saving and consequently sustainable growth.

Postharvest technologies are of great importance, since some help to keep fruit quality through storage without additional energy consumption [2]. However, they should be applied in such way to avoid negative effects to human health and environment.

Usually, fresh horticultural products are stored at the lowest temperature which keeps them for long period with good quality, and are taken out from cold storage according to the market requirements. However, as it is in the case of the present research, energy saving, and consequently less harm to the environment, can be done by storing fresh horticultural products at higher temperatures in the case they are needed to be put in the market earlier. The products that will be commercialised later, should be the only ones stored at the lower temperatures.

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