Postharvest changes of fresh cilantro

Pedro Figueiredo[1], Cristina E. Couto[1], Adriano A. Saquet[1,2] & Domingos P.F. Almeida[1]

[1]Instituto Superior de Agronomia, Universidade de Lisboa, Tapada da Ajuda, 1349-017 Lisboa, Portugal. dalmeida@isa.ulisboa.pt
[2]Instituto Federal de Educação, Ciência e Tecnologia Farroupilha – Campus Panambi, Rua Erechim, 860, 98280-000 Panambi, RS, Brazil.

Abstract

Cilantro (*Coriandrum sativum* L.) has become one of the most widely used fresh herbs worldwide. In addition to its flavorful culinary attributes, cilantro has been promoted by public health authorities as partial replacement of dietary salt intake. The objective of this study was to characterize the postharvest behavior of fresh cilantro to provide recommendations for proper postharvest handling.

Freshly harvested cilantro leaves were bunched into 50 g bunches held by a rubber band, wrapped in plastic, cooled to *ca*. 5 ºC and transported to the laboratory within 2 h after harvest. The leaf bunches were placed at 0º, 10º, and 20 ºC, and assessed for mass loss, ethylene production rate, respiration rate, color, and chlorophyll content. Hedonic assessment of appearance and odor were also performed.

Under these experimental conditions, fresh mass declined at a rate of 1.1; 1.5; and 6.3% per day, at 0º, 10º and 20 ºC, respectively. Ethylene production rate remained stable during storage at 0º or 10 ºC, at 0.26 and 1.61 µL kg^{-1} h^{-1}, respectively. At 20 ºC, the initial ethylene production rate of 4.04 µL kg^{-1} h^{-1} increased sharply after 4 days to reach 25.64 µL kg^{-1} h^{-1} at day 7 due to fungal development. The initial respiration rate, expressed in mL CO_2 kg^{-1} h^{-1}, was 7.7 at 0 ºC, 27.8 at 10 ºC and 114.1 at 20 ºC, and remained relatively stable during storage at 0 and 10 ºC. However, respiration rate double during 7 days at 20 ºC due to decay. The initial hue angle of cilantro leaflets was 124.7º, a value that remained relatively constant during 30 days at 0 ºC, but decreased slightly (2 to 3%) after 15 days at 10 ºC or 4 days at 20 ºC. The initial SPAD index of 42.2 decreased to 37.7 after 4 days at 20 ºC, to 35.6 after 15 days at 10 ºC and to 39.6 after 30 days at 0 ºC. Total chlorophyll content at harvest was 1.92 mg g^{-1} with a ratio of chlorophyll *a* to chlorophyll *b* of 3.2. Chlorophyll content decreased slightly at 10º and 20 ºC, mainly due to the reduction in chlorophyll *b* but remained unaltered during 30 days at 0 ºC. The duration of postharvest life based on appearance was 1.6; 7.3, and 11 days at 20º, 10º and 0 ºC, respectively. However, odor was judged at the sales limit after 1.0; 2.0; and 9.0 days at 20º, 10º, and 0 ºC, respectively.

In conclusion, the main causes of shelf-life termination are odor suppression and fungal development. Wilting can be reduced by packaging and senescence-related chlorophyll loss and yellowing are slower than odor suppression. Freshness is best preserved at 0 ºC.

Keywords: chlorophyll, *Coriandrum sativum,* coriander, ethylene, respiration.

Introduction

Cilantro, a traditional herb of Mediterranean origin, is one of the most widely used fresh herbs in the world. Its production has been increasing to meet the demand for international cuisine, for the mixed salads, and for flavorful culinary preparations. In addition, cilantro has been recommended as a flavoring herb to help reduce salt ingestion,

an important public health objective (Lopes et al., 2014). Therefore, postharvest behavior of cilantro becomes central for adequate supply chain management and consumer satisfaction.

Postharvest physiology of cilantro has been characterized. The respiration rate, expressed in CO_2 release, of cilantro maintained in air at 0 ºC decreases slowly from *ca*. 20 to 10 µl g^{-1} h^{-1} and at 5 ºC it ranges from 10 to 15 µl g^{-1} h^{-1}; at 10 ºC rates of 29 µl g^{-1} h^{-1} were reported and of 70 to 95 µl g^{-1} h^{-1} at 20 ºC (Loaiza & Cantwell, 1997). These rates are classified as moderately high. The rate of ethylene production is low, 0.1; 0.2; and 0.7 nL g^{-1} h^{-1} at 0º, 5º, and 10 ºC, respectively (Loaiza & Cantwell, 1997). Ethylene production and respiration rates increase toward the end of shelf life due to decay (Loaiza & Cantwell, 1997).

Cilantro exposure to exogenous ethylene at 5 µl l^{-1} increases leaflets yellowing due to chlorophyll degradation and enhances decay at 10 ºC but not at 0 ºC for 6 days (Loaiza & Cantwell, 1997).

Considering this metabolic behavior, cilantro shelf-life is severely limited at temperatures above 0 ºC. Controlled atmosphere with an oxygen partial pressure of 3 kPa does not improve the quality of shelf-life of cilantro (Loaiza & Cantwell, 1997). Carbon dioxide partial pressures of 10 kPa induce damage (discoloration) after 7 days and 20 kPa CO_2 is injurious to cilantro (Loaiza & Cantwell, 1997). Therefore, temperature management remains fundamental for adequate postharvest management of fresh cilantro.

This study aimed to characterize the effect of temperature on major postharvest changes of fresh cilantro leaves, and to identify the most important causes of shelf-life termination.

Materials and methods

Plant material and storage conditions. Freshly harvested cilantro (*Coriandrum sativum* L.) leaves were bunched into 50 g bunches held by a rubber band, wrapped in plastic and cooled to *ca*. 5 ºC and transported to the laboratory within 2 h after harvest. Four bunches of cilantro were placed inside plastic crates and stored in cold rooms at 0º, 10º and 20 ºC.

Fresh mass. Samples were weighed with a precision balance Kern PFB 200-3 and relative fresh weight was estimated as the ratio between each measurement and the initial weight.

Ethylene measurement. Ethylene production rate was measured in a closed system at the storage temperature. Headspace air (0.1 mL) was sampled with a syringe and ethylene measured by gas chromatography (Trace 1300, Thermo Fisher Scientific Inc., Marietta, USA) with a TG bond alumina (Na2SO4) capillary column (Thermo Fisher Scientific Inc., Marietta, USA) equipped with a FID detector.

Respiration rate. Carbon dioxide release was measured in a closed system with an infrared sensor with an Oxycarb 6 analyser (Isolcell Italia, Laives, Italy).

Color measurement. Color (CIE-Lab) of the leaflets was measured with a CR 400 tristimulus colorimeter (Konica-Minolta, Tokyo, Japan).

Measurement of SPAD index. A hand-held chlorophyll meter (SPAD-502 Plus, Konica-Minolta, Tokyo, Japan) was used to determine the index in three leaflets per sample.

Chlorophyll content. Three leaflets from each of the four replicated samples per treatment were excised and grounded with mortar and pestle. Chlorophyll was extracted in 30 ml of 80% acetone, after homogenization and a 30 min incubation in the dark. The homogenate was then filtered and centrifuged at 2600g at 4 ºC for 15 min. The supernatant

was recovered and diluted in 3 volumes of 80% acetone prior to spectrophotometric readings at 663.6 and 646.6 nm (CE 1011, 1000 series, Cecil Instruments, Cambridge, UK). Chlorophylls a and b and total chlorophyll contents were calculated according to Yang et al. (1998).

Hedonic assessment. Appearance and odor were assessed using a 7-point hedonic scale, with 7 being fresh-like appearance and odor, 5 the sales limit, 3, the consumption limit, and 1 very poor appearance due to wilting, yellowing, or decay, and intense off odor.

Results and discussion

Fresh mass. The rate of fresh mass change was 6.3; 1.5, and 1.1% d^{-1} at 20º, 10º, and 0 ºC, respectively (Figure 1). A water loss of 15% renders cilantro leaves unusable.

Ethylene production and respiration rates. Initial rate of ethylene production was 0.6; 1.7; and 4.0 µl kg^{-1} h^{-1} at 0º, 10º, and 20 ºC, respectively. Ethylene production rate remained relatively stable or declined slightly during shelf-life, expect when fungal development become evident (Figure 2A). The initial respiration rate was 11.4; 27.8; and 114.1 ml kg^{-1} h^{-1}, respectively at 0º, 10º, and 20 ºC (Figure 2B).

Color. The lightness (L*) of cilantro leaflets increased slightly, from 39.8 at harvest to 42.9 after 4 days at 20 ºC, 44.6 after 15 days at 10 ºC and to 41,8 after 29 days at 0 ºC (data not shown). Chroma also increased slightly during shelf-life, from an initial value of 25.6 to 30.0 after 4 days at 20 ºC, 33.2 after 15 days at 10 ºC e to 28.7 after 29 days at 0 ºC (not shown). The hue angle decreased slightly from 124.8 º at harvest to 122,7 after 4 days at 20 °C, 121.3 after 15 days at 10 ºC and to 123.3 after 29 days at 0 °C (Figure 3).

Chlorophyll content. Chlorophyll content of cilantro leaves was assessed nondestructively with a SPAD and destructively, after acetone extraction. The initial SPAD index was 42.2, a value that remained relatively constant or decreased slightly during shelf-life (Figure 4A). The initial chlorophyll content was 1.92 mg g^{-1} (Figure 4B). Chlorophyll content decreased to 1.79 mg g^{-1} after 4 days at 20 ºC, to 1.64 mg g^{-1} after 15 days at 10 ºC and had a value of 1.93 mg g^{-1} after 29 days at 0 ºC.

Hedonic assessment. The hedonic assessment of appearance and odor decreased at a faster rate the higher the temperature (Figure 5). It is noteworthy that odor scorings decreased faster than appearance.

Shelf-life. Shelf-life termination of cilantro can be based on several criteria. Three criteria were considered for shelf-life termination in cilantro: appearance, odor, and water loss. The end of shelf-life was attained when the hedonic score for appearance and odor was 5 or when the leaf bunches had lost 15% of fresh mass, corresponding to the limit of acceptable wilting. Shelf-life ranged from 1 to 2.4 days at 20 ºC, 2 to 10.3 days at 10 ºC and 9 to 13.3 days at 0 ºC (Table 1). Irrespective of storage temperature, shelf-life based on odor was shorter that based on overall appearance or water loss.

Conclusions

Temperature had a strong effect on cilantro quality preservation and shelf-life duration. At 0 ºC shelf-life is substantially extended due to lower respiration rate. Changes in color and related chlorophyll content did not limit shelf-life under any of the temperature conditions; instead, odor and wilting were the major causes of shelf-life termination in fresh cilantro.

References

Loaiza, J. & Cantwell, M. 1997. Postharvest physiology and quality of cilantro (*Coriandrum sativum* L). HortScience 32: 104-107.

Lopes, A., Teixeira, D., Calhau, C., Pestana, D., Padrão, P., Graça, P. 2014. Ervas aromáticas- uma estratégia para a redução do sal na alimentação dos portugueses. Direção-Geral da Saúde, Lisboa.

Yang, M., Chang, K., Yin, M., & Huang, H. 1998. Methods for the determination of chlorophylls and their derivatives. Taiwania 43: 116-122.

Tables and figures

Table 1- Shelf-life of cilantro leaves at 0º, 10º, and 20 ºC based on appearance, odor, and mass loss.

Temperature (ºC)	Duration of shelf-life (day)		
	Appearance	Odor	Mass loss
0	11.9	9.0	13.3
10	6.6	2.0	10.3
20	1.6	1.0	2.4

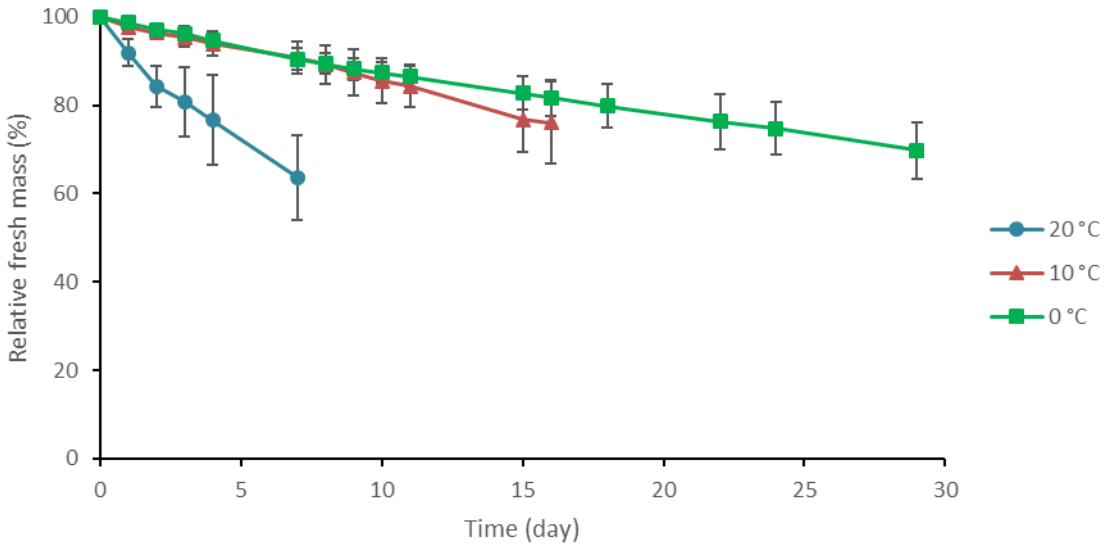

Figure 1- Decrease in relative fresh mass of cilantro at 0º, 10º, and 20 ºC.

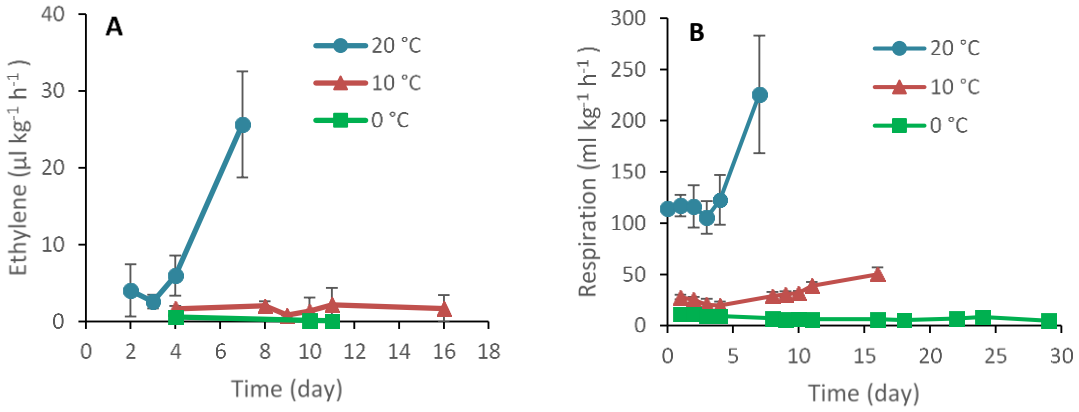

Figure 2- Ethylene production (A) and respiration (B) rates of cilantro at 0º, 10º, and 20 ºC.

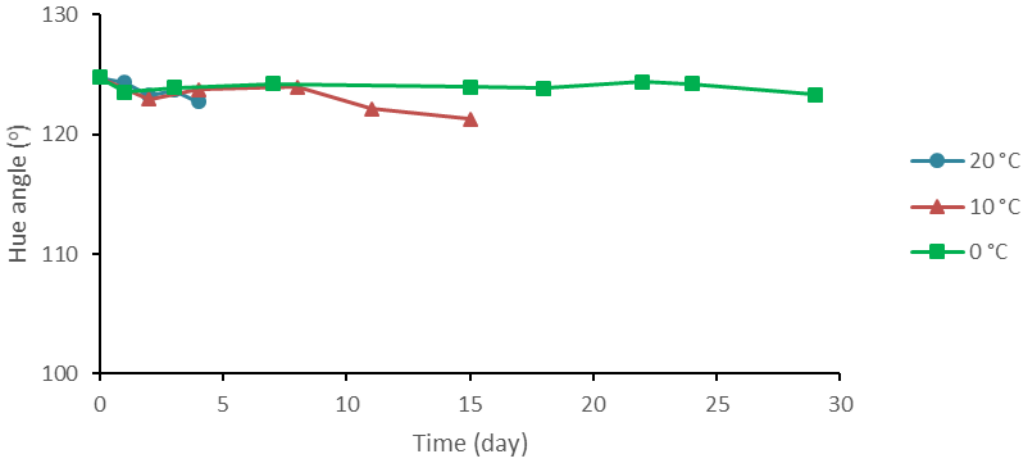

Figure 3- Hue angle of cilantro leaflets during shelf-life at 0º, 10º, and 20 ºC.

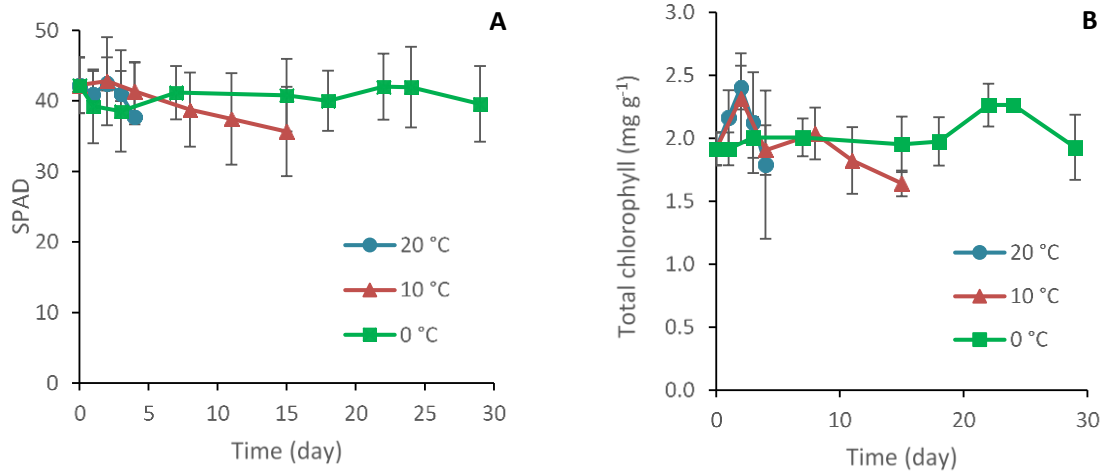

Figure 4- Chlorophyll content assessed nondestructively by SPAD (A) and determined spectrophotometrically (B) during shelf-life of cilantro leaves at 0º, 10º, and 20 ºC.

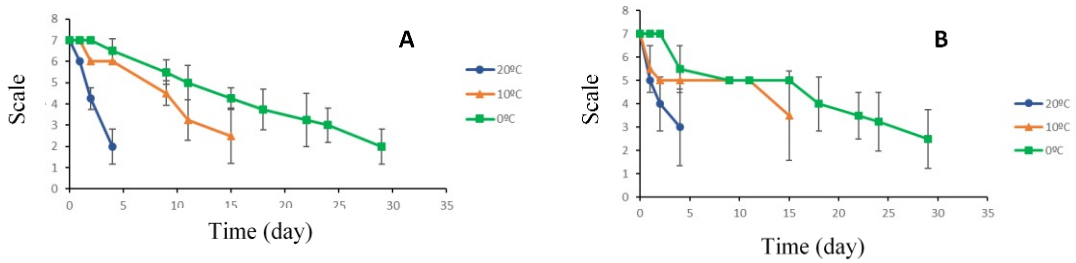

Figure 5- Changes in appearance (A) and odor (B) during shelf-life of cilantro at 0º, 10º, and 20ºC.