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Water relations in post-harvested torch ginger affected by harvest point and carnauba wax

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ABSTRACT

The use of post-harvest techniques that enhance quality and longevity of cut flowers is essential for successful marketing. However, for some species the most appropriate procedures are still unknown. The aim of this work was to evaluate the storability and post-harvest quality of flower stems of torch ginger harvested at two stages of flower opening, treated or not with carnauba wax, and stored at 16 or 21 °C. Carnauba wax (0, 0.75, 1.5 and 3.0% w/v) was applied to flowers at two stages of opening (semi-open and open bracts). Evaluations were performed every other day for 20 d. Visual quality was analysed by means of a grading scale; and relative fresh weight, water absorption, transpiration, water balance and bract anatomy were assessed. Carnauba wax was deposited as epicuticular sheets, but its application had no effect on the physiological or visual quality of the floral stems. Semi-open stage provided better visual quality for a larger number of days during the tested period of storage, along with physiological responses that contributed to the improvement of post-harvest longevity.

1. Introduction

Torch ginger (*Etlingera elatior* (Jack) RM Sm) can be harvested at different stages of floral opening. Unopened inflorescences (for modeling) and semi-open inflorescences show better post-harvest life compared with those harvested when fully open (Ribeiro et al., 2012). The life of a cut flower is influenced not only by opening stage but also by water stress, which results in wilting (Nowak and Rudnicki, 1990). Water deficit in plants can be attributed to greater transpiration compared with absorption since this affects water balance (Sankat and Mujaffar, 1994). To minimize this process, wax coating can be used to reduce water loss and increasing vase life, as already observed in cut 'Trinidad Pink' anthuriums (Mujaffar and Sankat, 2003).

Carnauba wax is a non-toxic material consisting of alcohols, fatty acids and esters (Chen and Nussinovitch, 2001; Blum et al., 2008). It is a commercially used by flower growers despite the lack of scientific evidence concerning its efficacy or post-harvest effects on torch ginger. Wax coating modifies the gas concentration in the free space around the product leading to a reduction in O_2 concentration and an increase in CO_2. The resulting decrease in of respiration, transpiration, ethylene biosynthesis and growth of microorganisms enhances the maintenance of quality and increases longevity (Chitarra and Chitarra, 2005). Depending on the concentration of wax, the film deposited on the product may alter gas permeability (water vapor, O_2 and CO_2) (Amarante et al., 2001) and improve the aesthetics of the product by intensifying the shiny appearance (Chen and Nussinovitch, 2000). The technique of modifying the atmosphere around a product by coating is often concurrent with refrigeration (Chitarra and Chitarra, 2005).

Low storage temperatures, reduce the rate and, consequently, slows down the processes of senescence. Thus, rapid cooling of the product straight from the field, accompanied by storage under cold conditions, can ensure the quality and longevity of flowers (Reid, 2009). For tropical flowers, the storage temperature should not be below 13 °C (Loges et al., 2005), depending on the species, since lower temperatures cause chilling injury leading to symptoms such as discoloration and necrotic lesions (Nowak and Rudnicki, 1990).

The influence of stage of floral opening on post-harvest quality of tropical flowers (Carneiro et al., 2014), and the effects of carnauba wax on the physiological processes of such flowers,

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remain unclear. Hence, the aim of this study was to evaluate the effects of carnauba wax on the physiological aspects of torch ginger applied at different concentrations and at two floral opening stages with storage at two different temperatures.

2. Materials and methods

Floral stems of the torch ginger (*Etlingera elatior*) cultivar 'Porcelana', presenting a light pink satin color, were harvested from a commercial flower farm and cleaned by dipping in water tank. Floral stems bearing semi-open and open inflorescences were cut to standard length of 60 cm and rehydrated by standing upright in containers of clean water. Inflorescences were subsequently immersed for 20 s in solutions of carnauba wax prepared by diluting a commercial carnauba wax product (Aruá® BR Tropical, 15%) with clean water to yield treatment solutions containing 0.75, 1.5 and 3.0% (w/v) wax. The control treatment did not receive carnauba wax treatment. Treated stems were maintained in an inverted position to allow excess liquid to drain off, and subsequently dried, weighed and placed in an upright position inside capped plastic vessels containing 600 mL of clean water. Two experiments were set up using equivalent treatments with storage kept for 20 d at 16 or 21 °C and relative humidity of 85 ± 5% during the experiment.

2.1. Quality analysis

The floral stems were evaluated every two days by three independent researchers following predefined criteria (Unemoto et al., 2011) adapted by Carneiro et al. (2014) as follows: grade 4 (excellent) – stems and inflorescences with normal turgidity and bracts of characteristic gloss and color; grade 3 (good) – start of loss of turgidity as determined by touch, with or without loss of color and/or wilting at the borders of bracts and stems; grade 2 (regular) – decline of bracts evidenced by visible loss of turgidity and glossiness of the inflorescences and stems, with bract borders appearing drenched; grade 1 (poor) – pronounced loss of turgidity by bracts and/or stems, bracts with translucent borders and inflorescences with soft central portions; grade 0 (bad/discard) – soft and/or dried bracts with/without drenched appearance, rotting of the central portions of inflorescences, abscission of bracts.

2.2. Anatomical studies

To assess anatomical features intrinsic to the pattern of wax deposition, one external bract from a single floral stem in each of the treatment groups was selected. Sample preparation and analysis were performed according to the method described by Alves (2004). Samples were analysed and images obtained using a Zeiss model EVO 40 VXP scanning electron microscope.

2.3. Physiological analysis

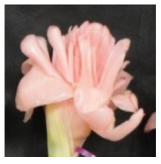
Every other day until the twentieth day, the floral stems were weighed and the data expressed as percentages relative to the initial fresh weight, following the method described by He et al. (2006), to obtain the relative fresh weight (%) from the expression $(M_t/M_{t=0}) \times 100$, where M_t is the mass (g) of the floral stem measured at the time corresponding to the day of evaluation and $M_{t=0}$ is the mass (g) of the same floral stem measured on day 0 of evaluation. To determine water absorption, the volume of water absorbed (V) was measured every two days and replenished to 600 mL.

Using the data relating to the fresh weight and the volume absorbed, it was possible to calculate the volume transpired from: Transpiration = V − (M_f − M_i), where V is the volume of water absorbed at each evaluation (mL), M_f is the mass (g) of the floral stem measured at the time corresponding to the day of evaluation, and M_i is mass (g) of the floral stem measured on the previous evaluation. Water balance was calculated as the difference between the absorbed volume (V) and the transpired volume (T). The absorbed and transpired volumes, along with the water balance, were expressed in mL d^{-1} evaluated per stem.

2.4. Experimental design and statistical analysis

Two stages of flower opening and four carnauba wax concentrations were used in a factorial design. Each treatment was randomly allocated to four experimental plots, each one consisting of two floral stems per plot. Each plot was evaluated

Table 1
Characterization of the visual appearance of torch ginger according to grades of evaluation. Grades: 4 (excellent) – stems and inflorescences with normal turgidity and bracts of characteristic gloss and color; 3 (good) – start of loss of turgidity as determined by touch, with or without loss of color and/or wilting at the borders of bracts and stems; 2 (regular) – decline of bracts evidenced by visible loss of turgidity and glossiness of the inflorescences and stems, with bract borders appearing drenched; 1 (poor) – pronounced loss of turgidity by bracts and/or stems, bracts with translucent borders and inflorescences with soft central portions; 0 (bad/discard) – soft and/or dried bracts with/without drenched appearance, rotting of the central portions of inflorescences, abscission of bracts.

Grade	Floral opening	
	Semi-open	Open
4		
3		
2		
1		
0