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Storage temperature and type of cut affect the biochemical and physiological characteristics of fresh-cut purple onions

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ABSTRACT

Minimal processing of onion (*Allium cepa* L.) results in convenience and freshness in a single product. However, inappropriate storage of fresh-cut onion results in losses of nutritional and sensory characteristics. To further understand this phenomenon, we evaluated the effect of the storage temperature and type of cut on the quality of fresh-cut purple onions. Purple onions (cv. Crioula Roxa) were minimally processed using two types of cut (10 mm cubes and 3–5 mm thick slices) and stored at different temperatures (0, 5, 10 and 15 °C) with 85–90% relative humidity (RH) for 15 days. The following analyses were performed to evaluate the shelf life of the purple onion: pungency, total phenolic content, anthocyanin content, quercetin content, respiratory rate, color, soluble solids content, titratable acidity, pH, dryness and deterioration index (DDI), and decay index (DI). Fresh-cut onions stored at 0 °C showed less pungency, lower respiratory rate levels and less variation of total phenolic, anthocyanin and quercetin contents. In addition, the physicochemical aspects and appearance changed less with fresh-cut onions stored at 0 °C. Moreover, slicing enabled a higher stability of the physicochemical and biochemical aspects in comparison to dicing. Storage of slices at 0 °C allowed preservation for up to 15 days.

1. Introduction

Onions (*Allium cepa* L.) are mainly consumed in raw salads as a condiment or for seasoning. However, when preparing the onion bulbs for consumption, volatile compounds that cause irritations on contact with human nostrils and eyes are released. Another drawback is the onion's odor that can saturate the handler's hands for a period of time. One way to overcome these problems is the use of minimally processed onions, which makes the product more convenient and ready for consumption while maintaining its freshness.

At present, many fresh-cut vegetables, such as carrots, lettuce, leaf mixes, garlic, beets, broccoli, cabbage and cauliflower are commercially available in different types of cuts, including cubes, slices, matchsticks and shreds. With regard to consumption habits, the appearance and use of the final product must be considered to determine the type of cut that will be used for a fresh-cut food. This choice must be based on the knowledge of the vegetable's physiology and biochemistry to ensure that the products show the expected quality (Silva et al., 2011).

In Brazil and in other developing countries, the cold chain is not well established, especially during marketing. Interruption of the cold chain leads to significant loss in the quality and reduction of shelf-life of the product, which is most likely the main barrier for an increase in marketing and consumption of fresh-cut products in these countries.

Fresh-cut onions cut into 0.7 cm thick slices and stored at −2, 4 and 10 °C under modified atmospheres show yellowing, loss in firmness and an increase in microbial population growth with increasing temperatures (Liu and Li, 2006). At present, the effect of temperature on other quality attributes, in particular flavor and flavonoid content, has not yet been studied. Likewise, a comparison of the effects of the various types of cut has not been reported. Therefore, a study of this fresh-cut vegetable is necessary to understand the main changes in product quality and the resulting consequences for the consumer.

In the present study, we evaluated the effects of storage temperature and type of cut on the quality of fresh-cut purple onion. We also identified the main changes resulting from inadequate storage conditions to demonstrate that the use of an appropriate storage

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temperature may prolong the shelf-life of fresh-cut onions without significant loss of quality.

2. Materials and methods

2.1. Raw material

Purple onions (*A. cepa* L., cv. Crioula Roxa) produced in the municipality of Ituporanga in the State of Santa Catarina, Brazil were used in this study. After harvest, the onions were left in windrows to dry and cure for eight days. Their tops were then cut off, and the onions were sorted (with diameters from 50 to 80 mm) and placed in 20 kg plastic fiber bags. The onions were taken to the laboratory, subjected to a selection process discarding the damaged bulbs and subsequently stored at 10 °C for one day.

2.2. Minimum processing and storage conditions

The onions were subjected to minimal processing using two types of cuts as follows: 3–5 mm thick slices and 1.0 mm edge cubes. After processing, 100 g of diced and 200 g of sliced onion were weighed and placed into rigid polypropylene containers with $320.0 \pm 0.5\ cm^3$ and $1190.0 \pm 0.5\ cm^3$ capacity, respectively, these were then capped with a cover of the same material. The thicknesses of the polypropylene containers was 0.2 mm in the lateral dimension, 0.4 mm in the base and 0.35 mm in the cap. The cap was not an airtight gasket, allowing gas exchange with the atmosphere. The onions were stored in four different cold rooms at 0, 5, 10 or 15 °C and 85–90% relative humidity (RH) for 15 days. The experiment consisted of eight treatments (two types of cut and four storage temperatures). Each analysis was composed of four replications (using one container for each replication) with the exception of respiratory activity, which comprised five replications of 200 g per sample.

2.3. Biochemical analysis

The analysis of pungency was performed one day before processing (day −1) for initial characterization, at the processing day (day 0) and every three days, using the method described by Schwimmer and Weston (1961) and modified by Anthon and Barrett (2003). The results were expressed in micromoles of pyruvic acid per gram of fresh matter (fm).

The total phenolic content was determined using the methodology of Singleton and Rossi (1965), except that the extracting agent was replaced with distilled water. The results were expressed in gallic acid equivalents (GAE), i.e. milligram of gallic acid per 100 g of fm. The anthocyanin and quercetin contents were quantified by the method of Lees and Francis (1972), and the results were expressed as mg $100\ g^{-1}$. These analyses were performed at day zero and then every three days.

2.4. Physiological analyses

The determination of respiratory rate was performed daily. Fresh-cut onions were placed in 500 mL hermetic glass jars previously exposed to the temperature and humidity conditions of the experiments. The jars were periodically sealed for 1 h. A silicone septum was fitted to each jar lid through which 0.5 mL of gas sample was collected using a 1 mL syringe. Each collected sample was injected into a Thermo Electron Corporation gas chromatograph (model Trace GC Ultra) equipped with two flame ionization detectors (FIDs). The results were calculated based on the chromatographic analysis, the mass of onions in the jars and the period of time during which the jars remained sealed. The results were expressed as mg $kg^{-1}\ h^{-1}$ of CO_2.

The soluble solids content (%), titratable acidity (% of pyruvic acid) and pH were determined at day zero and at every three days, according to the methodology of AOAC (2010).

To evaluate the onion color, a Minolta Chroma Meter CR-400 colorimeter was used. The values of luminosity (L^*), chromaticity (C) and hue angle ($^\circ h$) were determined at day zero and at every three days. Six slices were analyzed per replication, and two readings were performed for each slice. In the case of the diced onions, ten readings (five of the top cubes and five of the bottom cubes) were performed for each container.

The appearance was evaluated at day zero and at every three days, for 18 days, classifying the onions according to two indices. The dryness and deterioration index (DDI) was determined using the methodology of Miguel and Durigan (2007). A scale from 1 to 5 was used to classify DDI as follows: 1 = great (bright sample with typical coloration and turgid); 2 = good (bright with typical coloration and mild dryness); 3 = regular (strong smell but not unpleasant; more pronounced dryness); 4 = bad (intense dryness, tenderness, appearance of rot, atypical staining and moisture accumulation on the packaging); and 5 = very bad (dull and shriveled with rot and unpleasant smell). The decay index (DI) scale varied from 0 to 2 as follows: 0 (zero) = absence of visual rot; 1 = evidence of rot (superficial viscous aspect); and 2 = visible presence of rot (appearance of colonies).

2.5. Statistical analysis

The experimental design was completely randomized with an 8 × 6 factorial scheme (treatments × days of analysis). For pungency, DDI and DI analysis, the experimental design was 8 × 7 (treatments × days of analysis) and for respiratory rate, the experimental design was 8 × 16 (treatments × days of analysis), these designs was completely randomized too. The results obtained were subjected to analysis of variance (ANOVA), and the means were compared by Tukey's test ($p < 0.05$) using SAS statistical software (version 9.3; SAS Institute, Cary, NC, USA).

3. Results

3.1. Pungency, phenolic compounds and flavonoids are influenced by storage temperature and time

To determine the influence of storage temperature and time on the physiology of fresh-cut onion, we studied the most important changes in its characteristics through the evaluation of the main biochemical aspects of the onion. The pungency was influenced by storage temperature and time and by type of cut (Fig. 1). The sliced

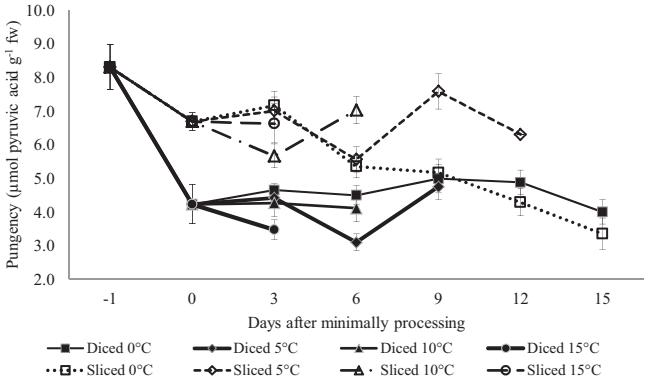

Fig. 1. Pungency of fresh-cut (diced or sliced) 'Crioula Roxa' onion stored at different temperatures and 85–90% RH for 15 days. Vertical bars represent the standard error ($n = 4$). −1 = before minimal processing.