Revista Iberoamericana de Tecnología Postcosecha
ISSN: 1665-0204
rbaez@ciad.mx
Asociación Iberoamericana de Tecnología
Postcosecha, S.C.
México

Cut type and storage temperature on the quality of minimally processed onions

Dallocca Berno, Natalia; Orsi, Bruna; de Abreu Vieira, Allan Patrick; Baldassin, Samira; Kluge, Ricardo Alfredo
Cut type and storage temperature on the quality of minimally processed onions
Revista Iberoamericana de Tecnología Postcosecha, vol. 20, no. 2, 2019
Asociación Iberoamericana de Tecnología Postcosecha, S.C., México
Available in: https://www.redalyc.org/articulo.oa?id=81361553011

Reportes Procesamiento

Cut type and storage temperature on the quality of minimally processed onions

Tipo de corte y temperatura de almacenamiento en la calidad de cebolla mínimamente procesada

Natalia Dallocca Berno [1]
University of São Paulo, Brasil
natalia.berno@usp.br

Bruna Orsi [2]
University of São Paulo, Brasil

Allan Patrick de Abreu Vieira [3]
University of São Paulo, Brasil

Samira Baldassin [4]
University of São Paulo, Brasil

Ricardo Alfredo Kluge [5]
University of São Paulo, Brasil

Redalyc: https://www.redalyc.org/articulo.oa?id=81361553011

Received: 24 June 2019
Accepted: 22 September 2019
Published: 15 December 2019

Abstract:

Minimal processing of onion is a good alternative to provide convenience to the consumer. However, processing steps, such as cutting, can contribute to the rapid deterioration of the product. In this sense, this study aimed to verify the influence of different cutting types and storage temperatures on the main quality aspects of fresh-cut onion. For this, onions were cut into cubes (diced) and slices (sliced) and then, stored at 0, 5, 10 or 15ºC. Physicochemical characteristics, visual and biochemical attributes of quality were accessed until the end of the shelf life. Results showed that the physiological changes were accelerated with the diced cut, due to the more intense physical stress caused by this type of cut. In addition, temperature also influenced the quality of fresh-cut onions, in which lower temperatures led to prolonged shelf life. The temperature of 0°C ensured better quality for the onions, however, the temperature of 5 °C is the most recommended since it has shown similar results, but also allows greater flexibility for the storage of other products.

Keywords: *Allium cepa* L, fresh-cut, shelf life, temperature, pungency.

Resumen:

Author notes

1 University of São Paulo, "Luiz de Queiroz" College of Agriculture, Piracicaba-SP, Brazil.

2 University of São Paulo, "Luiz de Queiroz" College of Agriculture, Piracicaba-SP, Brazil.

3 University of São Paulo, "Luiz de Queiroz" College of Agriculture, Piracicaba-SP, Brazil.

4 University of São Paulo, "Luiz de Queiroz" College of Agriculture, Piracicaba-SP, Brazil.

5 University of São Paulo, "Luiz de Queiroz" College of Agriculture, Piracicaba-SP, Brazil.

Corresponding author. Tel.: +55 19 34294136; fax: +55 19 34294100. E-mail address: natalia.berno@usp.br (N.D. Berno).

El procesamiento mínimo de la cebolla es una buena alternativa para ofrecer comodidad al consumidor. Sin embargo, los pasos de procesamiento, como el corte, pueden contribuir al rápido deterioro del producto. En este sentido, este estudio tuvo como objetivo verificar la influencia de diferentes tipos de corte y temperaturas de almacenamiento en los aspectos principales de la calidad de la cebolla recién cortada. Para esto, las cebollas se sometieron a pasos de procesamiento mínimos y se cortaron en cubos o rodajas en el paso de corte. Durante el almacenamiento, las cebollas se almacenaron a 0, 5, 10 o 15 ° C y se accedió a las características fisicoquímicas y los aspectos visuales y bioquímicos de la calidad hasta el final de la vida útil. Los resultados mostraron que los cambios fisiológicos se aceleraron con el corte cortado en cubos, debido al estrés físico más intenso causado por este tipo de corte. Además, la temperatura también influyó en la calidad de las cebollas recién cortadas, en las que temperaturas más bajas condujeron a una vida útil prolongada. La temperatura de 0 °C aseguró una mejor calidad para las cebollas, sin embargo, la temperatura de 5 °C es la más recomendada ya que ha mostrado resultados similares, pero también permite una mayor flexibilidad para el almacenamiento de otros productos.
Palabras clave: *Allium cepa* L, frescos cortados, vida útil, temperatura, acritud.

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most consumed vegetables in the world, appreciated for its flavor and used in salads, seasonings, soups and several other types of prepares. Initial procedures are necessary for onion consumption such as washing, peeling and slicing, in which the release of volatile compounds may occur. In contact with human eyes and nostrils, these volatile compounds cause irritations and, along with the odor that remains on the skin for prolonged periods, these factors are inconvenient to the consumer (Bahram-Parvar and Lim, 2018; Siddiq et al., 2013).

To overcome these problems, minimally processed products (MPPs), also called fresh-cut products, are an alternative, which provides greater convenience to the consumer, in addition to maintaining the characteristics of a fresh food. The market for minimally processed products has been growing steadily, and convenience and quality are important factors involved with the rise of these products (Ragaert et al., 2004). Research indicates changes in the profile of consumers who, while turning their attention to healthy foods, have less time available to prepare them (Buckley et al., 2007). In this sense, the MPPs are a good alternative, considering the processes carried out during their acquisition, which do not require initial procedures by the consumer.

Despite the practicality, the cutting of fresh onions causes mechanical injuries that can trigger biochemical and physiological changes and affect quality aspects, reducing the shelf life of the product. In addition, cutting can serve as an input source for microorganisms that cause rot and release toxins (Ölmez and Kretzschmar, 2009).

The use of low temperatures during storage is one of the main strategies to be used in order to conserve minimally processed products. Previous work reports the influence of temperature on the maintenance of coloration and control of microorganisms in fresh-cut onion (Liu and Li, 2006), as well as aspects related to flavor and nutritional properties of fresh-cut purple onions (Berno et al., 2014).

Considering the accelerated deterioration of minimally processed products, the objective of this study is to verify the influence of different types of cutting and storage temperatures on the main aspects of fresh-cut onion quality.

MATERIAL AND METHODS

Raw material

Onions (*Allium cepa* L. cv. Crioula Vermelha) cultivated in Ituporanga, Santa Catarina, Brazil, were used in this study. Bulbs were harvested and left in the field for 8 days for the healing process. Subsequently, they were selected, classified by caliber (50 to 70 mm) and transported to the laboratory. In the laboratory, bulbs were inspected for deformities and rot, packed in HDPE (high density polyethylene) containers and stored at 10°C for one day for field heat removal.

Minimal processing and experiment description

Onions were minimally processed in a refrigerated environment at 10°C and under adequate hygienic-sanitary conditions. they were cut into two different shapes: slices (3 to 5 mm thick) and dices (10 mm edge) using automatic cutter (Robot Coupe®, CL50E).

After processing, the onions were packed in polypropylene containers, with internal volume of 320.0 ± 0.5 cm^3 and 1190.0 ± 0.5 cm^3, for dices and slices, respectively. An amount of 100 g of diced onion, and 200 g of sliced onion, were packed. The thicknesses of the polypropylene containers were 0.2 mm thick on the sides, 0.4 mm thickness on the base and 0.35 mm on the cover, in both cases. The lid did not have a good seal, thus allowing the exchange of gases with the atmosphere.

The packages were randomly distributed in cold chambers previously cooled at 0, 5, 10 and 15°C and 85-90% RH, totaling 8 treatments (2 types of cut x 4 storage temperatures).

Analysis were performed on the day of processing and then every three days for 18 days, except for the analysis of pungency, which was also performed before processing (day -1), for characterization of the batch, and for the respiratory rate that was performed daily.

Experimental slope was the completely randomized, factorial scheme 8 x 7 (treatments x periods of analysis). For the analysis of pungency, the factorial scheme was 8 x 8 (treatments x analysis periods) and for the respiratory rate, 8 x 18 (treatments x analysis periods). Four replicates were used consisting of one package each, except for the respiratory rate analysis, which used five replicates of 200 g, regardless of the type of cut.

Analyses

The color was performed using the Minolta Chroma Meter CR-400 colorimeter to determine the following parameters: Luminosity (L*), chromaticity (C) and Hue angle or color (°h). Two readings were performed on each slice of onion, in all 6 slices per replicate and 10 readings in each package of onion cubes, with five readings on the top cubes and five readings on the bottom.

Soluble solids (°Brix), titratable acidity (% pyruvic acid) and pH were performed according to the methodology of AOAC (2010).

The appearance of the minimally processed onion was evaluated by the assignment of visual notes, using two parameters. The evaluation of dryness and deterioration (RD) was determined according to Miguel and Durigan (2007), with a scale varying from 1 to 5, being 1 = optimal (shiny and turgid sample with typical coloration); 2 = good (shiny sample with typical coloration, but with slight dryness); 3 = regular (strong, but not unpleasant smell, and more pronounced dryness); 4 = bad (intense dryness, softening and appearance of rot, atypical coloration and accumulation of moisture in the packaging); and 5 = poor (opaque, withered, with rotting and unpleasant smell). The incidence of rot was evaluated according to Berno et al. (2014), with a scale varying from 0 to 2, with 0 (zero) = visual absence of rot; 1 = signs of rot (viscous surface appearance); and 2 = visible presence of rot (appearance of colonies).

The quantification of total phenolic compounds (equivalent of gallic acid (EGA) per 100 g of fresh mass) was determined by the method developed by Singleton and Rossi (1965), modifying the extractive agent for distilled water.

The analysis of pungency was made according to Schwimmer and Weston (1961), considering the modifications proposed by Anthon and Barrett (2003). Results were expressed as µmol of pyruvic acid per gram of fresh mass. The pungency was quantified before processing (day -1) for initial characterization of the batch on the day of processing (day 0) to characterize the product and then every 3 days along the storage.

For the determination of respiratory rate, fresh onions were placed in 500 mL hermetically sealed glass vials, which were sealed for 1 hour. Samples of 0.5 mL of the headspace of the vial were injected into a gas chromatograph (Thermo Electron Corporation, Trace GC Ultra) equipped with flame ionization detectors (FIDs). The results were calculated based on the chromatographic data of authentic CO_2 standards. The results were expressed as mg CO_2 kg^{-1} h^{-1}.

Statiscal analyses

Results were submitted to analysis of variance (ANOVA) and means were compared by the Tukey test ($p < 0.05$), using SAS statistical software (version 9.3; SAS Institute, Cary, NC, USA).

RESULTS

Physicochemical characteristics

The analyzes of soluble solids, titratable acidity, pH, darkening index and respiratory rate were used to evaluate the effect of storage temperature on the physiological changes that occurred during the shelf life of minimally processed onions.

Soluble solids content reduced throughout storage, for both diced and sliced onion (Table 1). Regarding the type of cut, the diced onions resulted in higher losses of soluble solids than the sliced, which is explained by the greater mechanical damage that results in greater stress and increased metabolism, as well as more damaged cells.

The titratable acidity (Table 1) had low variation for sliced onions. However, diced onions presented a slight increasing tendency over time. In addition, for both cuts the higher the storage temperature the higher variation of this parameter. Except for 0 and 5°C, which maintained the titratable acidity more stable.

In parallel to the titratable acidity, there was a reduction of the pH during the storage, being more intense for diced onions (Table 1). The sliced onion kept the pH more stable throughout the storage.

TABLE 1
Soluble solids, titratable acidity and pH of diced or sliced fresh-cut onions submitted to different storage temperatures.

Time (Days)	Treatments 0°C Diced	0°C Sliced	5°C Diced	5°C Sliced	10°C Diced	10°C Sliced	15°C Diced	15°C Sliced	Mean
				Soluble solids (°Brix)					
0	10,85	10,85	10,85	10,85	10,85	10,85	10,85	10,85	10,85 A
3	9,35	10,68	9,10	10,73	9,90	10,45	9,90	10,18	10,03 AB
6	9,75	10,43	9,65	11,63	9,65	10,88	-	-	10,33 AB
9	9,78	10,40	9,53	10,78	-	-	-	-	10,12 AB
12	9,38	10,35	-	11,58	-	-	-	-	10,43 AB
15	9,75	10,00	-	-	-	-	-	-	9,88 B
18	-	9,93	-	-	-	-	-	-	9,93 B
Mean	9,81 c	10,38 abc	9,78 c	11,11 a	10,13 bc	10,73 ab	10,38 abc	10,51 abc	
C.V (%)	6,54								
				Titratable acidity (%pyruvic acid g^{-1})					
0	0,207 CDb	0,284 ABa	0,207 Ab	0,284 Aa	0,207 Bb	0,284 Aa	0,207 Bb	0,284 Aa	
3	0,199 Dcd	0,250 Bb	0,195 Ad	0,233 Bbc	0,180 Bd	0,197 Bcd	0,350 Aa	0,275 Ab	
6	0,242 BCbc	0,253 Bb	0,187 Ad	0,205 BCcd	0,325 Aa	0,208 Bcd	-	-	
9	0,306 Aa	0,309 Aa	0,189 Ab	0,212 BCb	-	-	-	-	
12	0,261 ABa	0,265 ABa	-	0,187 Cb	-	-	-	-	
15	0,270 ABa	0,248 Ba	-	-	-	-	-	-	
18	-	0,257 Ba	-	-	-	-	-	-	
C.V. (%)	7,39								
				pH					
0	5,34 Ab	5,67 Aa	5,34 Ab	5,67 Aa	5,34 Bb	5,67 Aa	5,34 Ab	5,67 Aa	
3	5,27 Ab	5,31 Bb	5,27 Ab	5,56 Aa	5,53 Aa	5,65 Aa	4,63 Bc	5,27 Bb	
6	5,30 Ab	5,39 Bab	5,26 Ab	5,65 Aa	4,42 Cc	5,56 Aa	-	-	
9	5,10 Bc	5,36 Bab	5,26 Abc	5,48 Aa	-	-	-	-	
12	5,11 Bb	5,42 Ba	-	5,58 Aa	-	-	-	-	
15	5,04 Bb	5,34 Ba	-	-	-	-	-	-	
18	-	5,36 Ba	-	-	-	-	-	-	
C.V. (%)	0,94								

Means followed by the same upper case letter in the column and lower case in the row do not differ by Tukey's test (5%). Data transformation: Titratable acidity: -log (x); pH: log (x + 2).

Visual aspects of quality

The coloration was modified during storage (Table 2). Yellowing and translucency are the main visual quality changes observed in minimally processed onions (Blanchard et al., 1996; Liu and Li, 2006). The change from white to yellow color in the innermost portion of the onions was more intense when the cut in slices.

The values of L, which represent the luminosity, showed a tendency to fall on the diced onions, while the sliced cut kept the highest luminosity (Table 2). The chromaticity reduced with greater intensity to the diced cut and then remained in the same levels from the beginning until the end of the storage. In relation to the Hue angle, the values remained constant for the diced cut and reduced with the sliced cut. The reduction in Hue angle values and the change in chromaticity may indicate a yellowing, also observed by Miguel and Durigan (2007).

TABLE 2
Lightness (L *), chromaticity (C) and color angle (° h) of diced or sliced fresh-cut onions submitted to different storage temperatures.

Time (Days)	Treatments 0°C Diced	0°C Sliced	5°C Diced	5°C Sliced	10°C Diced	10°C Sliced	15°C Diced	15°C Sliced
				Lightness (L*)				
0	58,01 Ab	69,43 ABCDa	58,01 Ab	69,43 Ba	58,01 Ab	69,43 Ba	58,01 Ab	69,43 Aa
3	48,55 BCc	67,54 CDb	49,86 BCc	73,00 Aa	49,61 Bc	74,14 Aa	48,28 Bc	69,18 Ab
6	50,35 BCb	71,65 ABa	44,54 Cb	70,67 ABa	43,92 Bb	70,31 Ba	-	-
9	46,59 Cc	71,96 Aa	53,02 Bb	71,85 ABa	-	-	-	-
12	45,26 Cc	68,90 BCDb	-	72,60 Aa	-	-	-	-
15	52,80 Bb	70,54 ABCa	-	-	-	-	-	-
18	-	66,74 Da	-	-	-	-	-	-
C.V. (%)	10,74							
				Chromaticity (C)				
0	14,87 Aa	14,33 Aa	14,87 Aa	14,33 Aa	14,87 Aa	14,33 Aa	14,87 Aa	14,33 Aa
3	11,28 Bd	12,18 Bcd	12,20 BCcd	14,38 Aab	11,77 Bcd	14,70 Aa	12,95 Bbc	15,04 Aa
6	11,62 Bb	13,65 ABa	11,05 Cb	14,68 Aa	11,73 Bb	15,27 Aa	-	-
9	11,71 Bb	14,66 Aa	13,52 ABa	15,02 Aa	-	-	-	-
12	11,78 Bb	14,16 Aa	-	14,90 Aa	-	-	-	-
15	12,46 Bb	14,29 Aa	-	-	-	-	-	-
18	-	15,00 Aa	-	-	-	-	-	-
C.V. (%)	7,22							
				Color Angle (°h)				
0	115,74 Ba	116,22 ABa	115,74 Ba	116,22 Aa	115,74 ABa	116,22 Aa	115,74 Aa	116,22 Aa
3	117,60 Aa	116,82 Aa	117,35 ABa	114,35 Bb	116,95 Aa	114,15 Bb	113,79 Bbc	112,23 Bc
6	117,83 Aa	116,36 ABab	117,56 Aa	115,26 ABb	114,86 Bb	112,12 Cc	-	-
9	117,09 ABa	115,20 BCbc	116,66 ABab	113,99 Bc	-	-	-	-
12	115,66 Ba	115,27 ABCab	-	113,70 Bb	-	-	-	-
15	116,78 ABa	114,61 CDb	-	-	-	-	-	-
18	-	113,56 Da	-	-	-	-	-	-
C.V. (%)	0,94							

Means followed by the same uppercase letter in the column and lower case in the row do not differ by Tukey's test (5%).

The incidence of rot was visually perceptible at day 3 for both cuts stored at 15° C (Figure 1A). For storage at 10ºC, there was evidence of rot on the ninth day, regardless of the type of cut used. At 5ºC, diced onions presented incidence of rot on the twelfth day, while for sliced, incidence was observed on the 15th day. For the temperature of 0ºC, the diced onion presented incidence in the 18th day, and the sliced onion presented incidence only in the 21st day.

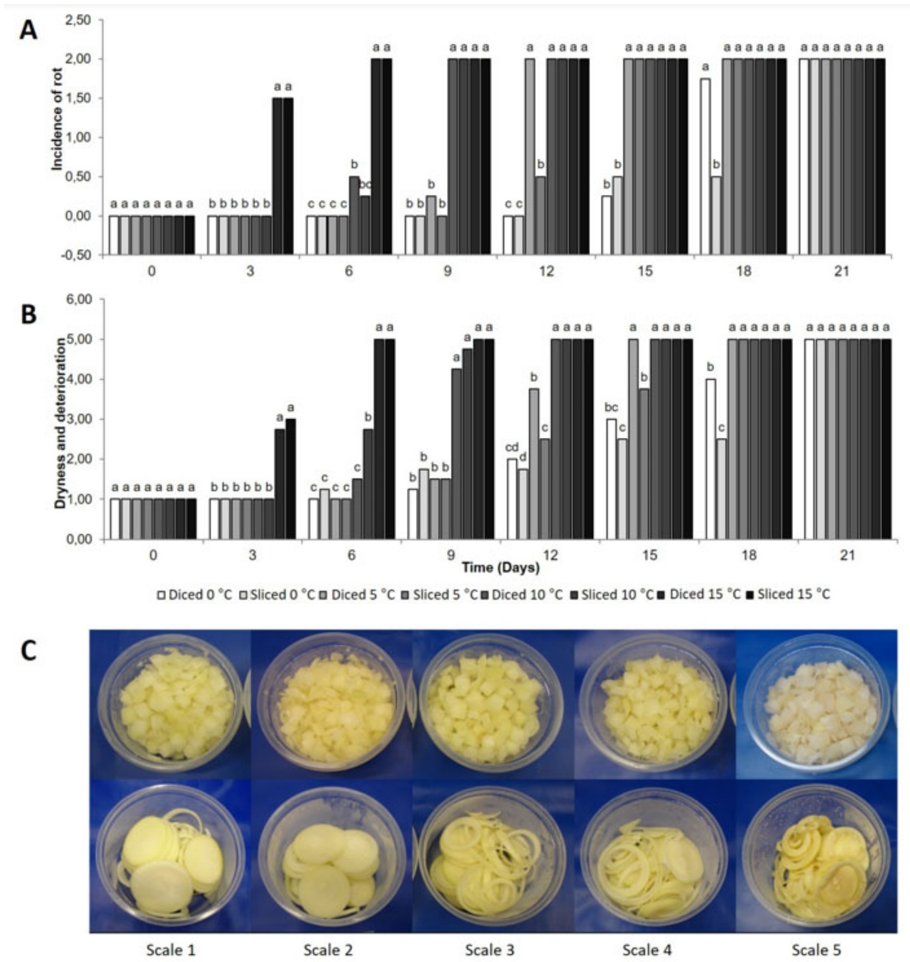

FIGURE 1

Visual aspects of diced and sliced fresh-cut onion and submitted to different storage temperatures.

(A) Mean of scales of rot incidence, which: 0 (zero) = visual absence of rot; 1 = signs of rot (viscous surface appearance); and 2 = visible presence of rot (appearance of colonies). (B) Mean of scales of dryness and deterioration, which: 1 = optimal (bright and turgid sample, with typical coloration); 2 = good (shiny sample with typical coloration, but with slight dryness); 3 = regular (strong, but not unpleasant smell, and more pronounced dryness); 4 = bad (intense dryness, softening and appearance of rot, atypical coloration and accumulation of moisture in the packaging); and 5 = poor (opaque, withered, with rotting and unpleasant smell). (C) Appearance of the fresh-cut onions of each of the scales of dryness and deterioration. Means followed by the same letter do not differ by Tukey's test (5%). Data transformation: $x^{0.5}$.

The diced cut received acceptable dryness and deterioration notes only on day zero for the temperature of 15 °C (Figure 1B and C). At temperatures of 10, 5 and 0 °C, the indexes were only accepted until the sixth, ninth and eighteenth day, respectively. For slicing, the acceptable grades were up to the third, sixth, twelfth and eighteenth day, at 15, 10, 5 and 0 ° C, respectively.

Biochemical and physiologic aspects of quality

The content of phenolic compounds (Table 3) reduced for diced onion under the temperatures of 0, 5 and 10 °C, whereas for sliced onion the concentrations of these compounds remained constant.

The pungency was also changed between different temperatures and days of storage. In general, lower temperatures presented less pungency. In addition, a reduction in pungency was verified from day zero to day three, and after that, a slight increase was observed during storage (Table 3).

TABLE 3
Phenolic compounds and pungency of diced or sliced fresh-cut onions submitted to different storage temperatures.

Time (Days)	Treatments 0°C Diced	0°C Sliced	5°C Diced	5°C Sliced	10°C Diced	10°C Sliced	15°C Diced	15°C Sliced
	Phenolic compounds (mg EGA 100g^{-1})							
0	693,50 Aa	700,83 Aa	693,50 Aa	700,83 Aa	693,50 Aa	700,83 Aa	693,50 Aa	700,83 Aa
3	498,75 Bc	527,11 Bc	578,47 ABabc	674,46 Aa	557,06 Bbc	582,04 Aabc	643,52 Aab	678,03 Aa
6	491,22 Bc	613,97 ABab	523,34 Bbc	625,47 ABab	654,82 Ba	594,34 Aab	-	-
9	558,64 Ba	557,45 Ba	562,01 Ba	538,81 Ba	-	-	-	-
12	551,90 Bb	588,98 ABb	-	725,42 Aa	-	-	-	-
15	575,70 ABa	592,36 ABa	-	-	-	-	-	-
18	-	568,16 Ba	-	-	-	-	-	-
C.V. (%)	*11,45*							
	Pungency (µmol Pyruvic acid g^{-1})							
-1	5,75 Aa	5,75 Aa	5,75 Aa	5,75 Aa	5,75 Aa	5,75 Aa	5,75 Aa	5,75 Aa
0	2,89 Ccde	3,10 Ba	2,89 Ca	3,10 BCa	2,89 Ca	3,10 Ca	2,89 Ba	3,10 Ca
3	2,55 Cbc	2,41 CDe	3,26 BCbc	2,54 Cde	3,28 BCb	3,22 Cbcd	3,60 Bab	4,28 Ba
6	2,55 C	2,11 Dc	3,74 Ba	3,00 BCb	3,89 Ba	4,38 Ba	-	-
9	3,19 BCa	3,29 Ba	2,93 Ca	3,35 Ba	-	-	-	-
12	3,89 Bb	3,30 Bb	-	4,96 Aa	-	-	-	-
15	3,83 Ba	3,03 BCb	-	-	-	-	-	-
18	-	3,10 BCa	-	-	-	-	-	-
C.V. (%)	*3,53*							

Means followed by the same uppercase letter in the column and lower case in the row do not differ by Tukey's test (5%). Data transformation: phenolic compounds: x^{-1}; pungency: $(\log(x+2))^{0,5}$.

After two days of storage, the respiratory rate of onions stored at 15°C was the highest, regardless of the type of cut. On the third day, when the onions stored at this temperature were discarded, both types of cut presented the highest respiratory rate (Table 4). At the sixth day of storage, both types of cut stored at 10°C also presented a high respiratory rate, being discarded afterwards. The onions stored at 0 °C, especially those sliced, maintained the lowest respiratory rates until the end of the experiment. The onions stored at 5 °C also had a lower respiratory rate, but a significant increase occurred from the sixth day of storage (Table 4).

TABLE 4
Respiratory rate of diced or sliced fresh-cut onions submitted to different storage temperatures.

Time (Days)	Treatments							
	0°C		5°C		10°C		15°C	
	Diced	Sliced	Diced	Sliced	Diced	Sliced	Diced	Sliced
	Respiratory rate (mL CO_2 kg^{-1} h^{-1})							
0	13,50 Ab	19,92 Aa	13,50 BCb	19,92 CDa	13,50 CDb	19,92 Ca	13,50 Db	19,92 Ca
1	4,59 EFGHc	6,91 BCDEb	3,64 Hc	4,52 Hc	4,79 Fc	6,84 Eb	18,10 Ca	21,41 Ca
2	3,80 GHd	6,02 CDEFc	5,80 FGc	6,22 GHc	8,86 Eb	11,15 Db	36,75 Ba	29,93 Ba
3	3,47 He	4,01 Gde	4,66 GHde	5,17 Hd	11,46 DEc	13,55 Dc	100,24 Aa	54,04 Ab
4	6,17 DEc	7,92 BCbc	7,04 EFbc	8,01 FGd	17,20 Ca	19,16 Ca	-	-
5	4,09 FGHc	5,09 DEFGc	7,25 EFb	8,72 EFb	24,86 Ba	27,46 Ba	-	-
6	5,35 EFc	6,48 BCDEc	9,10 DEb	8,95 EFb	58,31 Aa	54,73 Aa	-	-
7	4,08 FGHb	5,42 DEFGb	10,44 CDa	11,33 Ea	-	-	-	-
8	5,12 EFGb	6,61 BCDEb	18,21 Aa	15,62 Da	-	-	-	-
9	3,38 Hb	4,34 FGb	17,09 ABa	15,30 Da	-	-	-	-
10	4,69 EFGHb	5,55 DEFGb	-	25,71 BCa	-	-	-	-
11	5,61 EFb	6,37 BCDEb	-	52,03 Aa	-	-	-	-
12	6,03 DEb	6,82 BCDb	-	32,32 Ba	-	-	-	-
13	8,00 CDa	6,33 BCDEa	-	-	-	-	-	-
14	9,79 BCa	6,97 BCDb	-	-	-	-	-	-
15	11,43 ABa	8,48 Bb	-	-	-	-	-	-
16	-	5,76 DEFGa	-	-	-	-	-	-
17	-	6,91 BCDa	-	-	-	-	-	-
18	-	5,23 DFGa	-	-	-	-	-	-
C.V. (%)	*6,32*							

Means followed by the same uppercase letter in the column and lower case in the row do not differ by Tukey's test (5%). Data transformation: log(x+2).

DISCUSSION

The results of this experiment demonstrate the importance of the temperature used in minimally processed onion storage, but also demonstrate the implications of the cut type of the bulbs.

Diced onions presented physiological changes faster than sliced, due to the greater physical stress caused by this type of cut. It was also clear that lower temperatures prolonged the shelf life of the minimally processed onion, since diced onion storage extended for 3, 9, 12 and 18 days, at 15ºC, 10ºC, 5ºC and 0ºC, respectively. Similarly, for sliced onion the duration was 3, 9, 15 and 18 days, at 15ºC, 10ºC, 5ºC and 0ºC, respectively.

In addition to the physical stress, the cut causes disintegration of cells, leading to the elimination of the internal material and even affecting the soluble solids content (Toivonen and Deell, 2002). In addition, soluble solids are also used as a substrate source in respiration, for cellular metabolism, and the respiratory rate is closely related to temperature (Moretti, 2007). In this experiment it was also observed, where higher temperatures caused a higher respiratory rate, which explains why the higher temperatures have a greater reduction of soluble solids.

Also, the different temperatures and cut types modified the titratable acidity of the minimally processed onions, which tended to increase during the storage period, making the products taste more acidic. Similar results were found by Miguel and Durigan (2007) which studied minimally processed 'Superex' onion stored at 10ºC, produced with bulbs stored for different periods under ambient conditions (23°C, 65% RH).

In relation to the visual aspects, the coloring is one of the most decisive in the decision to purchase the minimally processed products (Bansal et al., 2015). The decrease in the luminosity of the onions minimally processed by both cutting types may have been caused by the superficial loss of water, since the samples showed to be dried over time. According to Moretti (2007), cutting stresses expose the hydrated inner tissues and increase the water evaporation rate. In addition, elevated temperatures cause greater water loss through transpiration (Tano et al., 2011).

It was also observed in this study that with the reduction of temperature, the rot becomes less visible, extending the shelf life of the product. According to Pelczar et al. (1998), temperatures near or below zero can retard the growth and metabolic activity of microorganisms. In addition, the type of cut also influences this parameter, and the greater the damage caused to the tissues, the faster the incidence of rot is visible.

One of the main factors observed in the appearance of the onion was the superficial dryness, being more evident in the slices, due to its disposition in the packaging. According to Moretti (2007), the first change that occurs in the appearance of minimally processed products is the desiccation of the first layer of damaged cells and from one to a few layers of nearby cells. This is widely observed in products such as carrots, beets, potatoes, onions, and asparagus. The main problem with this dry appearance is that many people associate whiteness with disease. The use of sharp cutting blades in processing may reduce such appearance.

The cut in the processing of the plants also produces a signal of stress that can be responsible for the induction of several physiological responses, among which we can mention the induction in the synthesis of phenolic compounds and the response of the vegetal tissue increases with severity of the stress caused. The use of the appropriate temperature can minimize the change of compounds throughout the storage (Moretti, 2007).

In summary, not only the temperature, but also the different types of cutting can change aspects of fresh-cut onion quality. In this study, factors associated with flavor, appearance, nutritional quality and safety of the food, which is represented by the absence of rot, were primarily affected by diced cut associated with elevated temperatures.

CONCLUSION

The temperature that best preserves minimally processed onion is 0ºC, and among the types of cut, the slice presents minor changes in quality aspects throughout the storage. However, maintenance of the minimally processed onion at 0 ºC becomes impractical, since several other minimally processed products, which are normally stored in the same place by the producers, would not support this condition. Thus, it is recommended the storage of minimally processed onions at 5ºC, which also extended the shelf life of the product.

Acknowledgments

To the Foundation for Research Support of the State of São Paulo (FAPESP) for the financing of this project (Process number 2010/12982-4) and the Coordination for the Improvement of Higher Education Personnel (CAPES), for financing through the FAPESP / CAPES agreement.

REFERENCES

Anthon, G.E., Barrett, D.M., 2003. Modified method for the determination of pyruvic acid with dinitrophenylhydrazine in the assessment of onion pungency. J. Sci. Food Agric. 83, 1210–1213. https://doi.org/10.1002/jsfa.1525

AOAC, 2010. The Official Methods of Analysis of AOAC INTERNATIONAL 18th. p. 2500.

Bahram-Parvar, M., Lim, L.-T., 2018. Fresh-Cut Onion: A Review on Processing, Health Benefits, and Shelf-Life. Compr. Rev. Food Sci. Food Saf. 17, 290–308. https://doi.org/10.1111/1541-4337.12331

Bansal, V., Siddiqui, M.W., Rahman, M.S., 2015. Minimally Processed Foods: Overview. pp. 1–15. https://doi.org/10.1007/978-3-319-10677-9_1

Berno, N.D., Tezotto-Uliana, J.V., dos Santos Dias, C.T., Kluge, R.A., 2014. Storage temperature and type of cut affect the biochemical and physiological characteristics of fresh-cut purple onions. Postharvest Biol. Technol. 93, 91–96. https://doi.org/10.1016/j.postharvbio.2014.02.012

Blanchard, M., Castaigne, F., Willemot, C., Makhlouf, J., 1996. Modified atmosphere preservation of freshly prepared diced yellow onion. Postharvest Biol. Technol. 9, 173–185. https://doi.org/10.1016/S0925-5214(96)00046-4

Buckley, M., Cowan, C., McCarthy, M., 2007. The convenience food market in Great Britain: Convenience food lifestyle (CFL) segments. Appetite 49, 600–617. https://doi.org/10.1016/j.appet.2007.03.226

Liu, F., Li, Y., 2006. Storage characteristics and relationships between microbial growth parameters and shelf life of MAP sliced onions. Postharvest Biol. Technol. 40, 262–268. https://doi.org/10.1016/j.postharvbio.2006.01.012

Miguel, A.C.A., Durigan, J.F., 2007. Qualidade de cebola minimamente processada e armazenada sob refrigeração. Hortic. Bras. 25, 437–441. https://doi.org/10.1590/S0102-05362007000300022

Moretti, C.L., 2007. Manual de Processamento Mínimo de Frutas e Hortaliças, 1st ed. Empresa Brasileira de Pesquisa Agropecuária, Brasília.

Ölmez, H., Kretzschmar, U., 2009. Potential alternative disinfection methods for organic fresh-cut industry for minimizing water consumption and environmental impact. LWT - Food Sci. Technol. 42, 686–693. https://doi.org/10.1016/J.LWT.2008.08.001

Pelczar, M., Chan, I.C.S., Krieg, Noel, R., 1998. Microbiology, 1st ed. Tata McGraw-Hill.

Ragaert, P., Verbeke, W., Devlieghere, F., Debevere, J., 2004. Consumer perception and choice of minimally processed vegetables and packaged fruits. Food Qual. Prefer. 15, 259–270. https://doi.org/10.1016/S0950-3293(03)00066-1

Schwimmer, S., Weston, W.J., 1961. Onion Flavor and Odor, Enzymatic Development of Pyruvic Acid in Onion as a Measure of Pungency. J. Agric. Food Chem. 9, 301–304. https://doi.org/10.1021/jf60116a018

Siddiq, M., Roidoung, S., Sogi, D.S., Dolan, K.D., 2013. Total phenolics, antioxidant properties and quality of fresh-cut onions (Allium cepa L.) treated with mild-heat. Food Chem. 136, 803–806. https://doi.org/10.1016/j.foodchem.2012.09.023

Singleton, V.L., Rossi, J.A., 1965. Colorimetry of Total Phenolics with Phosphomolybdic-Phosphotungstic Acid Reagents, American Journal of Enology and Viticulture. American Society of Enologists.

Tano, K., Kamenan, A., Arul, J., 2011. Respiration and transpiration characteristics of selected fresh fruits and vegetables. Agron. Africaine 17, 103–115. https://doi.org/10.4314/aga.v17i2.1662

Toivonen, P., Deell, J., 2002. Physiology of Fresh-cut Fruits and Vegetables, in: Fresh-Cut Fruits and Vegetables. CRC Press. https://doi.org/10.1201/9781420031874.ch5

Funding

Funding source: Foundation for Research Support of the State of São Paulo (FAPESP)
Contract number: Process number 2010/12982-4

Funding

Funding source: Coordination for the Improvement of Higher Education Personnel (CAPES)