Sensory quality attributes of lettuce obtained using different harvesting performance systems

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Abstract

The objective of this study was to determine the best lettuce cultivar (American 'Graciosa', 'Vanda', 'Marcela' and 'Lavínia') harvesting method. Therefore, quality and shelf-life were evaluated using sensory analyses. Lettuce heads was harvested with the root on by the producer, so that they were cut in different ways in the laboratory. The samples were stored in a cold chamber at 10 °C and 80% ± 2% of relative humidity for nine days, and the sensorial analyses were performed according to Qualitative Descriptive Analysis method on days 1, 3, 6, and 9 of storage by twelve trained testers. The results were evaluated by variance analysis, principal component analysis, and the Tukey test with a reliability of 95%. The results indicate that there was a reduction in the quality of lettuce between the 1st and the 5th day of storage and that after the sixth day of storage the lettuce samples were considered unfit for consumption, except for the 'Lavínia' lettuce cultivar with root and cut treatment 2. On the ninth day of storage all samples were considered inappropriate for consumption.

Keywords: *Lactuca sativa* L.; shelf-life; quality.

1 Introduction

Among the vegetables widely consumed in Brazil is the lettuce cultivar *Lactuca sativa* L., a leafy vegetable belonging to the *Astereceae* family (FELTRIM et al., 2005).

In the state of Sao Paulo, the volume of commercialized leafy vegetables increased between 1999 and 2009 from 84 thousand to 136 thousand tons, totaling 63%. The Asteraceae family had the highest growth, from 27 thousand to 52 thousand tons, totaling 93% increase, and the lettuce reached 82% of the volume in 2009. (INSTITUTO…, 2008; SISTEMA..., 2010).

Fruits and vegetables are valued food because they play an important role in human nutrition and health. However, some are highly perishable, especially leafy vegetables, requiring attention and special handling in all stages of the production.

One of the reasons they are extremely perishable, besides their high water content, is that they are still alive even after harvest, thus maintaining their vital processes. Hence, they are forced to use their reserves of substrate (such as sugars and starch) to breathe and to produce necessary energy to stay alive (CHITARRA; CHITARRA, 2005).

When subjected to physical stresses, these products have their metabolism accelerated, leading to an increase in the respiratory rate causing faster deterioration (PORTE; MAIA, 2001).

The lettuce postharvest processing operations in tropical countries such as Brazil presents several challenges to those involved in the production and marketing chain due to the high perishability of this product. Moreover, the value of leafy vegetables is low in most markets, which makes difficult the adoption of more advanced techniques of postharvest (TIVELLI, 2007).

There are few similar studies related to this proposal since most of the studies on crop systems available in the literature are focused specifically on the product and productivity. There are very few studies on differentiated crop systems of lettuce plants or on the optimization and improvement of crop systems. Therefore, the present study aimed to compare the different processes of lettuce plant harvesting in order to verify the best system to prolong the useful life of lettuce plants.

Sensory analysis, a tool widely used due to its ease and speed of implementation, can be used for quality control. It is carried out in different stages starting from the receipt of raw materials up to finished products. The Qualitative Descriptive Analysis method (QDA) evaluates all the sensory attributes of food products, namely appearance, aroma, flavor, and texture.

In the sensory evaluation of lettuce, appearance has a major influence in choosing the product since brown spots on the leaves and extremities are factors that lead to the refusal to purchase the product (KADER, 2002; HEIMDAL et al., 1995). Thus, physiological parameters are associated to sensory quality, which are essential requirements for the acceptance and success of these products. This study aimed to evaluate the lettuce shelf life harvest process (cut in different ways - on the stem or with the whole root - using the traditional method of cutting in the control sample) under controlled conditions of temperature and relative humidity using sensory analyses.

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2 Materials and methods

The experiment was conducted at the Laboratory of Postharvest Technology (LTPC) of the School of Agricultural Engineering (FEAGRI), University of Campinas (UNICAMP), located at the University City "Zeferino Vaz," Barão Geraldo district, Campinas/SP, in September 2011. During that time, the maximum and minimum temperature of 27.8 °C and 15.8 °C, respectively, were detected in Campinas.

Four varieties of lettuce (American "Graciosa' (Tecnoseed), 'Vanda' (Sakata), 'Marcela' (Hortec), and 'Lavinia' (Sakata)) were used. The plants were obtained from a commercial plantation located on Sítio Noda s/n, Colônia Tozan, Mogi Mirim km 10, Campinas-SP.

All lettuce plants collected were grown under the same conditions the lettuce beds dimensions were 1.00 m/100 m, the number of vegetables per bed was 1.200 units, and the spacing between rows was 12 seedlings per m^2. Around 45 days after planting, they were harvested in the morning with the root on by the producer. The cut was performed ± 1 cm above the soil level using a knife. The most damaged outer leaves were discarded. Another cut was made (±3 cm) aiming at the removal of part of the stem that did not had leaves in order to obtain cleaner product.

The plants were transported to the LTPC in plastic boxes (40 × 60 × 23 cm; ten units per box). Next, the plants were rinsed with tap water and stored in cold chamber (Profrio Modular Serie 34512) under temperature and relative humidity of 10 °C ± 1 °C and 80% ± 2%, respectively.

Some samples were harvested with the root on and were cut in different regions at the laboratory: cut 1, root - stem transition, and cut 2, from the beginning of the root zone and the first leave. A caliper was used to standardize the cutting height with the distance of 1mm above the root (cut 1) and the distance of 15 mm (cut 2). The cuts were made by carbon steel blade, like a scalpel, sterilized.

The plants were analyzed on days 1, 3, 6, and 9 after harvest by a team of twelve trained testers.

The following visual attributes: color, freshness, mechanical damage, brightness, and general appearance were analyzed using the Qualitative Descriptive Analysis (QDA) (KADER, 2002; MEILGAARD; CIVILLE; CARR, 1999).

For the choice and definition of the concepts and attributes to be analyzed, the most important product qualities were taken into consideration.

The purpose was to train the testers using the same vocabulary to describe the sensory properties of the lettuce plants (Table 1). During the training, the concept of each attribute was also introduced through photos and lettuce samples that were selected according to the end-points of the scale used.

Next, an evaluation sheet composed of nine-point hedonic scale was used, in which the end points were lack of quality and excellence in quality. The same sheet model was used to each vegetable.

The experimental design consisted of a completely randomized in a 4 × 4 factorial arrangement (four varieties of lettuce - 'Graciosa', 'Vanda', 'Marcela' and 'Lavínia') and four different cuttings - with root on (WR); producer's cut (PC); cut on the stem -root transition (C1); and between the beginning of the root zone and the first leave (C2).

A total of 320 lettuce plants were analyzed, and they were acquired according to the number of replications and treatments (4 × 4 × 5 = 80); four varieties of lettuce, four harvest systems, and 5 repetitions, totaling 80 units per cultivar.

The results were subjected to descriptive analysis, and when it was confirmed that the data followed a normal distribution, the analysis of variance was performed and, if significant, the mean comparison between the treatments by the Tukey test with confidence level of 95% using the statistical ASSISTAT® version 7.6 beta (SILVA, 2011).

A multivariate analysis method, called principal component analysis (PCA), was also used; the data obtained in this study were analyzed using the R® software version 2.14.1 (R DEVELOPMENT…, 2011).

3 Results and discussion

According to Almeida (1995) and Gonzales, Burin and Buena (1999), the instrumental color can be used as a parameter to establish the quality standard of an *in natura* or processed product. It can also be used as a factor to determine the shelf life of a product, when variation during storage is studied.

The parameters freshness and brightness are also essential for product acceptance by the consumer, and they are directly

Table 1. Profile Attributes used in conventional lettuce, definitions, and references.

Attributes	Definitions	References
Color	Bright green color, characteristic of lettuce quality.	1: Absence of chlorophyll 2: Presence of chlorophyll
Freshness	Liveliness and brightness characteristic of the vegetables before losing vigor.	Wilt: Absence of freshness Fresh: Presence of freshness
Mechanical damage	Damage of any kind in the leaves, browning in the midrib and edges, and presence of lesions.	Damaged: Presence of damage Integrate: Absence of damage
Brightness	Characteristic of the vegetation when in good condition; when it gives the consumer a feeling of freshness and quality	Opaque: Absence of brightness Shiny: Presence of brightness

associated with the water present in vegetables. Moisture stress begins with the loss of moisture to the environment, which is characterized by the loss of turgidity, and therefore it is necessary to control the temperature and relative humidity in an attempt to maintain this parameter (THOMPSON, 2004).

Another important factor is the preservation of vegetables with regards to mechanical damage, which can be caused by many factors and at any time during the life cycle of raw materials. Any damage to the vegetable tissue induces physiological and biochemical activities resulting in deterioration of the product (PORTE; MAIA, 2001). Thus, good handling practices are essential throughout the production chain to assure food quality.

Considering all of the attributes mentioned above: color, brightness, freshness, and damage; it can be concluded that the general appearance is given by the grouping of these parameters perceived by the consumer. All of these factors and the customer's quality expectations are taken into account before purchasing.

The sensory profiles of the lettuce samples obtained by quantitative descriptive analysis are shown in the radar chart (Figures from 1 to 4). The center of the figure represents the point 1 of a range of attributes, while the intensity increases from the center to the periphery.

Every attribute analyzed had a tendency to linear regression. It can be said that this loss of quality is an expected result since quality cannot be improved; only maintained. Changes were observed in the lettuce plants over the storage period.

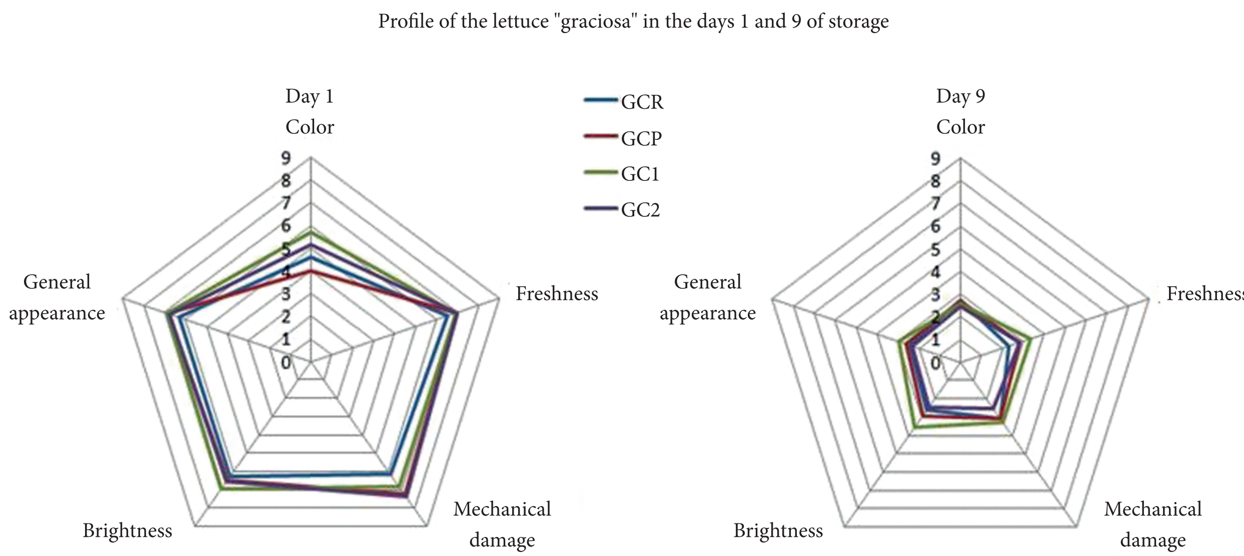

Figure 1. Sensory Profile of the Lettuce 'Graciosa' for the treatments With Root (WR), Producer's Cut (PC), Cut 1 (C1), and Cut 2 (C2).

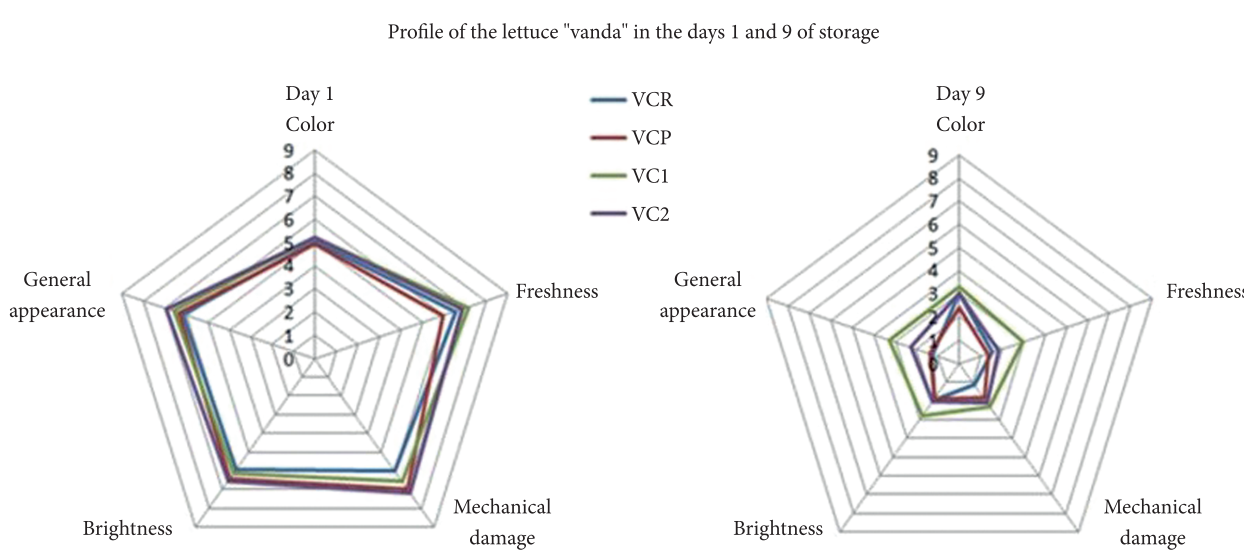

Figure 2. Sensory Profile of the Lettuce 'Vanda' for the treatments With Root (WR), Producer's Cut (PC), Cut 1 (C1), and Cut 2 (C2).

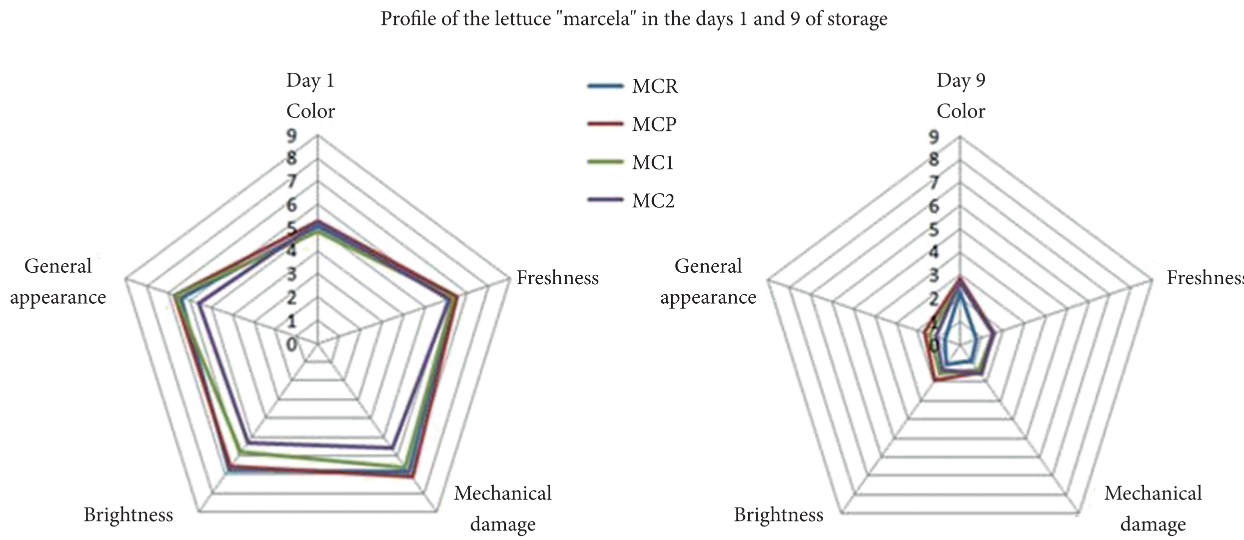

Figure 3. Sensory Profile of the Lettuce 'Marcela' for the treatments With Root (WR), Producer's Cut (PC), Cut 1 (C1), and Cut 2 (C2).

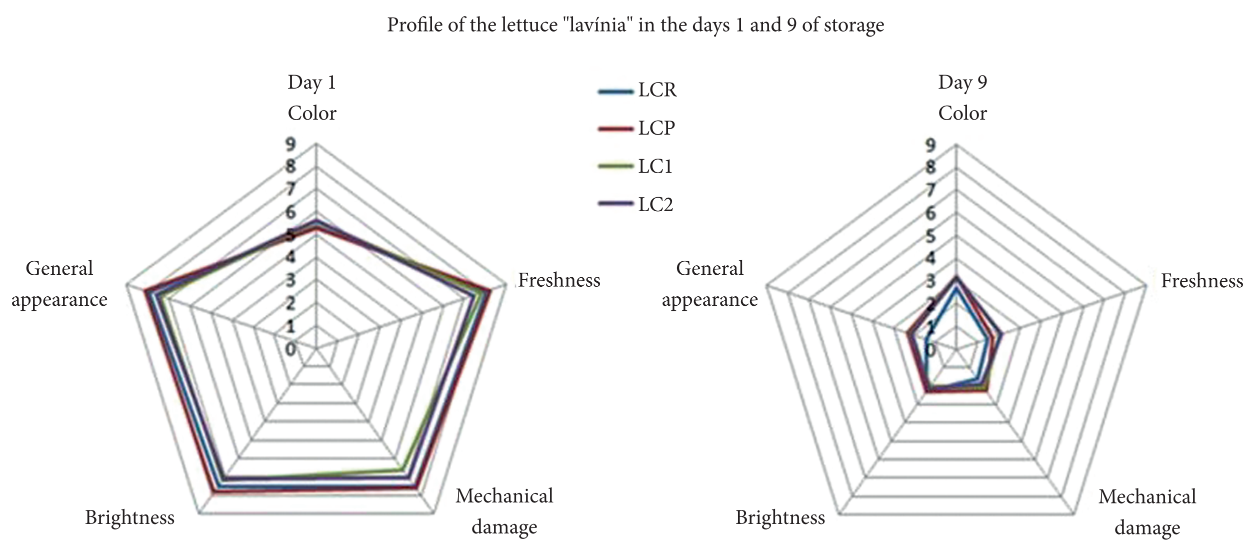

Figure 4. Sensory Profile of the Lettuce 'Lavínia' for the treatments With Root (WR), Producer's Cut (PC), Cut 1 (C1), and Cut 2 (C2).

According to Chitarra and Chitarra (2005), senescence is considered as a period of the life cycle of a vegetal when there is a predominance of catabolic processes (degradation), which are responsible for the death of tissues since the synthesis ability of a vegetal is very limited in the final stage of life.

Analyzing the results, it appears that the lettuce 'Marcela' (Figure 3) was more prone to degradation with notes concentrated in the center of the graph. This fact is attributed to the characteristics of leaf structure specific of each type of lettuce.

Regarding the general appearance parameter on the 9th day of storage, the lettuce 'Lavinia' (Figure 4) presented values ranging from 1.47 to 2.30; higher than those found for the lettuce 'Marcela' 0.73 to 1.70. The lettuce 'Graciosa' (Figure 1) presented values ranging from 2.31 to 2.95; the highest values were found for this attribute on the last day of analysis. The lettuce 'Vanda' (Figure 2) presented values from 1.25 to 3.28, highlighting the best performance of the cut 1 treatment, since the quality of this lettuce was maintained longer.

The literature on the sensory analyzes in whole lettuce plants is scarce; most studies focus on sensory analyses in minimally processed lettuce plants. However, scientific publications on postharvest changes are informative enough.

Significant differences ($p \leq 0.05$) were found for every attribute during the storage period, except for the American variety with root and the producer's cut for color parameter.

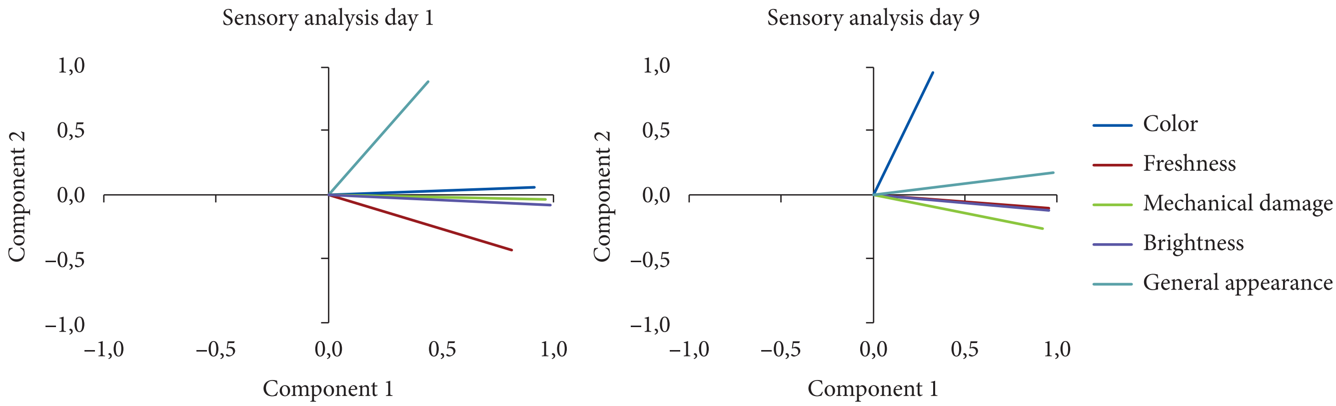

Figure 5. Principal Component Analysis graphs from the 1st and 9th days of storage.

Chlorophyll is responsible for the green color of plants. Since their chemical structure is unstable, they are easily degraded resulting in decomposition products that change the perception and food quality (SCHOEFS, 2002). This aspect is entirely related to the acquisition of these products by consumers; the decrease in chlorophyll content result in market losses, thus, encouraging research in an attempt to find methods to better preserve them.

It was observed that during the day the green color of the leaves decreases, as pointed out by Schoefs (2002). It can be said that the samples reached the 6th day of storage presenting acceptable color. According to Chitarra and Chitarra (2005), changes in pH, due to increased concentration of organic acids in the vacuoles, activation of the enzyme *chlorophyllase,* and endogenous oxidant systems, contribute to loss of color.

As for the attributes freshness and brightness during storage, it was observed loss of vigor associated with water loss. With regards to freshness, there were statistical differences ($p \leq 0.05$) between the treatments on the 3rd and 9th days for the lettuce 'Vanda', to which the producer's cut treatment presented the worst results.

After harvest, the loss of only 5 to 10% water is sufficient to cause changes in the structure, texture, and appearance (CHITARRA; CHITARRA, 2005). Thus, the reduction of water loss during storage is important for maintaining the vigor and quality of the products.

Guimarães et al. (2006), when working with sensory analysis of minimally processed lettuce stored at temperatures of 10 °C and 2 °C confirming that the two temperatures were efficient in maintaining the most of sensory qualities. However, it was observed a better performance during storage at 2 °C.

Once again, it is evident the importance of controlling the temperature and the ideal relative humidity during the storage of lettuce.

Mechanical damage was intensified during storage. It is importantly to emphasize that the level of damage will influence dramatically the shelf life of the product. The lettuce cultivar 'Vanda' presented statistically difference ($p \leq 0.05$) on the 6th day of storage, and the treatment with root had greater losses than those of other types of lettuce (2.57).

According to the hedonic scale, considering the undesirable values below 4.5, it can be said that regarding the general parameter aspect that on the 6th day of storage the lettuce plants were considered unfit for consumption, with the exception of the lettuce 'Lavínia' for the treatment with root and cut 2. On the 9th day of storage, all samples were considered improper for consumption.

It can be seen in Figure 5, similar performance between the attributes, represented in the graph by the vectors, the smaller the angle between the vectors, the greatest correlation between the attributes, i.e., the attributes freshness, mechanical damage, and brightness are strongly correlated.

4 Conclusion

The quality of lettuce plants reduced from the 1st to the 6th day of storage, and on the 6th day the plants in all treatments were considered inappropriate for consumption, with the exception of the lettuce 'Lavínia' in the treatments with the root and cut 2. On the 9th day of storage, all samples were considered unfit for consumption.

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