Postharvest Biology and Technology 49 (2008) 255–259

Contents lists available at ScienceDirect

Postharvest Biology and Technology

journal homepage: www.elsevier.com/locate/postharvbio

Failure criteria based on consumers' rejection to determine the sensory shelf life of minimally processed lettuce

Gastón Ares[a,b,*], Inés Martínez[b], Claudia Lareo[b], Patricia Lema[b]

[a] Sección Evaluación Sensorial, Cátedra de Ciencia y Tecnología de Alimentos, Facultad de Química, Universidad de la República, Avda. Gral. Flores 2124, C.P. 11800 Montevideo, Uruguay
[b] Instituto de Ingeniería Química, Facultad de Ingeniería, Universidad de la República, Julio Herrera y Reissig 565, C.P. 11300 Montevideo, Uruguay

ARTICLE INFO

Article history:
Received 25 April 2007
Accepted 18 February 2008

Keywords:
Butterhead lettuce
Sensory shelf life
Fresh-cut vegetables
Failure criteria
Consumer studies

ABSTRACT

The aims of the present work were to determine failure criteria based on consumers' rejection to purchase for shelf life estimation of minimally processed lettuce, and to compare criteria for whole and cut lettuce. A trained sensory panel and a consumer panel evaluated samples of whole and cut lettuce leaves packaged in passive modified atmosphere. In order to determine failure criteria to estimate sensory shelf lives, sensory attribute intensities corresponding to 25% consumers' rejection to purchase percentage were calculated using logistic regressions. Failure criteria values were lower for cut lettuce than for whole leaves for all the evaluated attributes, suggesting that consumers reacted differently towards whole and cut lettuce leaves, being stricter towards cut lettuce than towards whole lettuce leaves. These results indicate that sensory limits depended on the product considered and therefore a unique criterion should not be used to estimate the shelf life of both cut lettuce and whole lettuce leaves. Twenty-five percent of the consumers would refuse to purchase cut lettuce if the intensity of the evaluated defects was over 10% of the measuring scale, whereas scores of 25% of the scale were needed to achieve a 25% of consumer rejection in the case of whole leaves. These failure criteria were stricter than those traditionally used for sensory shelf life estimation of minimally processed lettuce, which might assure the products' quality at the end of its shelf life.

Results of the present study showed the importance of performing consumer studies in order to establish proper criteria to estimate the shelf life of fresh vegetables.

1. Introduction

In the last decade, the demand for fresh-like minimally processed fruits and vegetables has increased, mainly due to nowadays consumers' concern about health and convenience (Odumeru et al., 2002; Zhou et al., 2004). This fact has led to an increase in the quality and variety of products available to the consumers (Francis et al., 1999). Thus, efforts must be taken to ensure the quality of minimally processed products (Piagentini et al., 2005; Ragaert et al., 2004).

Minimally processed fruits or vegetables could be defined as fresh fruits or vegetables that have been processed to increase their functionality without greatly changing their fresh-like properties (Salunkhe et al., 1991). The most used processes are washing, cutting, mixing and packaging. These processes induce mechanical injury in the tissue changing its physiology, accelerating deterioration during transport and retailing, and consequently shortening their shelf life (Delaquis et al., 1999). The shelf life of minimally processed vegetables is generaly limited by changes in their sensory properties and not by microbial growth (King et al., 1991; Jacxsens et al., 1999, 2002).

Colour and appearance are critical quality aspects for shoppers when selecting fresh fruits and vegetables (IFT, 1990; Ragaert et al., 2004). Therefore, the shelf life of lettuce can be defined as the length of time for which lettuce can maintain an appearance that appeals to the consumer (Zhou et al., 2004).

Sensory shelf life of minimal processed lettuce could be determine as the time required for a certain sensory attribute to a certain predetermine intensity, or failure criteria (Hough et al., 2002). Traditionally, the sensory shelf life of minimally processed lettuce has been estimated considering as failure criteria 50% of the scale used to measure a sensory attribute (Barriga et al., 1991; Piagentini et al., 1997, 2004, 2005; Li et al., 2001; Jacxsens et al., 2002; Zhou et al., 2004). This criterion has been arbitrarily selected, and no studies have been found supporting the validity of using this failure criterion or correlating these sensory limits with consumers' perception.

* Corresponding author. Tel.: +598 2 9245735; fax: +598 2 9241906.
E-mail address: gares@fq.edu.uy (G. Ares).

0925-5214/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.postharvbio.2008.02.006

However, food products do not have sensory shelf lives of their own; shelf life depends on the interaction of the food with the consumer. Consumers are the ones that decide if they would consume a food product after a certain storage time. For this reason consumers are the most appropriate tool for determining food product sensory shelf life (Hough et al., 2003).

Although a consumer panel would seemingly be the most appropriate tool to determine the shelf life and quality of a food product, to repeatedly assemble consumer panels for multiple measurements would be both impractical and expensive. Although a sensory panel is more appropriate for repeated assessments, its results would be more analytical and not necessarily representative of consumer responses (Hough et al., 2002). By correlating data from a consumer panel with those obtained from a trained panel, these analytical measures can be used to determine the shelf life or quality of a food product. This would enable the determination of more objective failure criteria to estimate the shelf life of minimally processed vegetables, assuring products' sensory at the end of its shelf life.

The aims of the present work were to determine failure criteria based on consumers' rejection to purchase for shelf life estimation of minimally processed lettuce, and to compare criteria for whole and cut lettuce.

2. Materials and methods

2.1. Plant material, packaging and storage conditions

Butterhead lettuces (*Lactuca sativa* L., cv Wang) were obtained from a local farm near Montevideo (Uruguay). Within 24 h after harvest, lettuce was transported to the School of Engineering in Montevideo, Uruguay. Outer damaged and yellowed leaves and stems were removed. The remaining leaves were washed with cold chlorinated water (200 mg kg^{-1} total chlorine) for 10 min, and then rinsed with water. Lettuces were dried by centrifugation in a manual kitchen basket type centrifuge for 2 min. One half of the leaves were cut in pieces of approximately 3 cm × 2 cm using a sharp knife.

Approximately 70 ± 5 g whole lettuce leaves or cut lettuce leaves were selected at random and placed under air in 30 cm × 40 cm bioriented polypropylene (BOPP; two layers of 20 μm thickness) bags. BOPP films were provided by a local manufacturer. According to the supplier the BOPP gas transmission rates were 0.23–0.34 nL O_2 m^{-2} s^{-1} Pa^{-1}, 0.69–0.80 nL CO_2 m^{-2} s^{-1} Pa^{-1} (both at 23 °C and 101 kPa) and 17–35 μg H_2O m^{-2} s^{-1} (at 37 °C and 90% RH). Bags were sealed using a Supervac GK105/1 (Wien, Austria) packaging machine with air injection, and stored at 5 ± 0.5 °C and 90% relative humidity. Whole lettuce leaves were evaluated after 0, 10, 21, 28, 35, 42 and 49 d of storage; whereas evaluations for cut lettuce leaves were performed after 0, 3, 6, 8, 10, 13 and 17 d.

2.2. Trained sensory panel

Samples were evaluated by a panel of six assessors, who had previous experience in the evaluation of fresh vegetables.

At each storage time, a lettuce whole leave or approximately 20 g of randomly selected cut lettuce was presented to the assessors in a closed odourless plastic container labelled with three digit random numbers, at room temperature. The assessors had to evaluate the following attributes: off-odour, wilting appearance, presence of dark and necrotic stains on the leaf surface, presence of browning on the midribs. They also evaluated browning of the cut edges for cut lettuce samples. For scoring, 10 cm unstructured scales anchored with "nil" and "high" were used.

A balanced complete block design was carried out for duplicate evaluation of the samples. Testing was carried out in a sensory laboratory that was designed in accordance with ISO 8589 (1988). Evaluations were performed under artificial daylight type illumination, temperature control (between 22 and 24 °C) and air circulation.

2.3. Consumer panel

Consumers were recruited among students and workers from the Chemistry Faculty in Montevideo, Uruguay. The study was carried out using 40 people who consumed lettuce. Their ages ranged between 18 and 50 and they were approximately 50% female and 50% male.

At each storage time, each consumer received one leaf of lettuce, for each storage condition, in closed odourless plastic container, labelled with three digit random numbers. For each sample, consumers had to evaluate its appearance and respond "yes" or "no" to the question "Imagine you are in a supermarket. You want to buy a minimally processed lettuce, and you find a package of lettuce with leaves like these, would you normally buy it?".

2.4. Data analysis

2.4.1. Analysis of variance

For experimental data for whole and cut lettuce leaves, an analysis of variance was performed considering storage time as variation factor. Honestly significant differences were calculated using Tukey's test. Differences were considered significant when $p \leq 0.05$. This analysis was performed using Genstat Discovery Edition 2 (VSN International, Oxford, UK).

2.4.2. Sensory attribute development modelling

In order to model the development of the evaluated sensory attributes as a function of storage time, and to estimate the activation energy of these attributes, the following equations that assume zero (Eq. (1)) and first-order (Eq. (2)) reaction rate were used:

$$X = X_0 + k_T t \quad (1)$$

$$X = X_0 \exp(k_T t) \quad (2)$$

where X = value for the sensory attribute X at time t; X_0 = value for the sensory attribute X at time $t = 0$; k_T = reaction rate constant at storage temperature T; t = storage time;

In order to estimate the equation's parameters, linear and nonlinear regression facilities of Genstat Discovery Edition 2 (VSN International, Oxford, UK) were used.

2.5. Regression analysis

A logistic regression was carried out considering percentage of rejection (calculated as the proportion of consumers who answered "no" when asked if they would normally buy a package of lettuce containing cut or whole lettuce leaves like the ones they saw) as dependent variable, and the evaluated sensory attributes as explanatory variable (Gámbaro et al., 2006). The following equation was used:

$$\text{Logistic}: \text{Rejection percentage} = a + \left(\frac{b}{1 + e^{-c(X-d)}}\right) \quad (3)$$

where X is each of the evaluated sensory attributes, and a, b, c and d are the regression constants. This analysis was carried out using Genstat Discovery Edition 2 (VSN International, Oxford, UK).