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Influence of modified atmosphere packaging and storage temperature on the sensory and microbiological quality of fresh peeled white asparagus

A. Simón [a], E. Gonzalez-Fandos [b,*]

[a] Servicio de Investigación y Desarrollo Tecnológico Agroalimentario, Gobierno de la Rioja, Spain
[b] Food Technology Department, University of La Rioja, C/madre de Dios 51, 26006 Logrono, Spain

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ABSTRACT

The sensory and microbiological quality of fresh peeled white asparagus packaged in two different types of P-Plus films and stored at two different temperatures (5 °C and 10 °C) for up to 14 days, was studied. The shelf life limiting alterations at each temperature were evaluated. The best modified atmosphere was determined.

At 10 °C, the shelf life was 6 days, the loss of freshness was the main cause of quality loss, as indicated by colour darkening and presence of blotches. Moreover the sensorial acceptance of cooked asparagus was affected, being on the limit.

Fresh appearance was maintained better at 5 °C than at 10 °C, being microbial spoilage the main limiting factor. The atmosphere generated with film A (around 7% CO_2 and 15% O_2) inhibited spoilage and maintained the acidity of asparagus better than the atmosphere generated by film B (around 2% CO_2 and 20% O_2). The shelf life of asparagus packaged in film A and stored at 5 °C was 14 days.

Mesophiles and enterobacteriaceae counts in asparagus stored at 5 °C were acceptable during 14 days being around 7 log cfu/g. Mesophiles counts were slightly higher in asparagus stored at 10 °C than at 5 °C, while the increase in enterobacteriaceae was clearly higher in asparagus stored at 10 °C.

1. Introduction

White asparagus (*Asparagus officinalis*, L.) is a vegetable usually consumed as canned food in Spain, but can be also marketed as fresh peeled product that meets the increase in the consumer demand for ready to use vegetables. Fresh peeled white asparagus is a product that can be readily boiled, thus avoiding the tedious operation of peeling.

During asparagus storage it is important to maintain its freshness characteristics, because these can be easily lost due to its high respiration rate and metabolic activity. During storage at ambient temperature, this product quickly loses its quality due to water loss, increase in toughness and development of a purple colour in the apical section caused by anthocyanin synthesis (Chang, 1987; Siomos, Sfakiotakis, & Dogras, 2000). Changes in composition have also been observed during storage, such as the decrease in soluble solids and the increase in acidity (Simón, 1996, pp. 100–102) and the decrease in ascorbic acid and carbohydrates (Siomos et al., 2000). This loss of quality is also accompanied by microbial deterioration due to the spoilage caused by an enterobacteriaceae *Erwinia carotovora* (Suslow, 2001) or different mould species (Kadau, Huyskens-Keil, Gosmann, & Büttner, 2005). These undesirable changes can be reduced by storage at low temperatures (0–4 °C) and high relative humidity (Lipton, 1990).

It has been demonstrated that peeling of white asparagus does not increase respiration rate or ethylene production (Siomos, Gerasopoulos, Tsouvaltzis, & Koukounaras, 2008). Moreover, removing the outer portion of the stalk to get rid of the external defects or excessive fibrousness (Simón, González-Fandos, & Tobar, 2004; Siomos et al., 2008). However, peeling increases weight loss by dehydration (Siomos et al., 2008).

Packaging in semi-permeable films can partially avoid asparagus dehydration (Simón et al., 2004; Siomos et al., 2000). This is the main beneficial effect, but a passive modified atmosphere is also generated, which could be beneficial since it may prevent the development of pink colour in the apical section (Simón & Cerrolaza, 1994; Siomos et al., 2000). Moreover, modified atmospheres may inhibit mould growth, as reported by Kadau et al. (2005)

In previous studies, with whole (Simón & Celorraza, 1994) and peeled white asparagus (Simón et al., 2004) packed in microperforated polypropylene film (P-Plus), modified atmospheres with

* Corresponding author.
E-mail address: elena.gonzalez@daa.unirioja.es (E. Gonzalez-Fandos).

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high oxygen levels without anaerobiosis and with adequate CO_2 levels were reached. The atmospheres generated in these types of films depend on their permeability to gases according to the number of micro-perforations. It is important to know the most appropriate atmosphere in order to select film permeability. On other hand, it should be taken into account that temperatures in the marketing stage usually range from 5 °C to10 °C.

The aim of this work was to evaluate the sensorial and microbiological quality of fresh peeled white asparagus packaged in two different types of P-Plus films with different permeabilities when stored at two different temperatures (5 °C and 10 °C) for up to 14 days. The shelf life limiting factors, as well as the most beneficial atmosphere were determined.

2. Material and methods

2.1. Harvesting and processing of asparagus

White asparagus (*A. officinalis*, L.) of the Grolim variety were harvested from a 3-year old commercial plantation from Navarre (Spain). Harvesting was carried out early in the morning, asparagus spears of first quality and diameter of 13–17 mm were selected. Asparagus spears were cut to 16 cm in length and peeled. Peeling was performed manually in an industry near the laboratory by their own staff. Immediately after peeling, the asparagus were carried to the laboratory where they were washed with tap water to remove soil residues. After, asparagus were stored at 2 °C and 98% relative humidity (RH) for 24 h in order to reduce the respiration rate. The period at room temperature, between harvesting and cold storage, was 4 h.

The peeled asparagus were immersed in an aqueous solution of sodium hypochlorite containing 150 mg/l of free available chlorine for 8 min with slight manual agitation. Then, they were washed for 2 min with water to eliminate excess chlorine and placed on absorbent paper for 10 min to remove excess surface water.

Groups of eight spears (about 200 g) were placed in polystyrene trays measuring 140 × 230 mm. The trays were overwrapped with two polypropylene oriented micro-perforated films of 20 × 30 cm and 35 μm in thickness with different gas permeability. The film A had an O_2 transmission rate of 13200 ml m^{-2} day^{-1} atm^{-1} and film B 45000 ml O_2 m^{-2} day^{-1} atm^{-1}, the ratio between CO_2 and O_2 permeability was 1:1 and the water vapour transmission rate was 0.9 m^{-2} day^{-1}, according to the data provided by the manufacturer (Amcor-Flexibles Europe. Bristol, UK). Three trays were prepared for each treatment and sampling day for each experiment.

Packaged asparagus were stored at two different temperatures, 5 °C ± 1 and 10 °C ± 1, and 50% RH for up to 14 days.

All the determinations were carried out in three trays (three repetitions) by treatment and sampling day. The gases determination was performed on days 1, 6, 11 and 14. Texture, pH, acidity, sensorial evaluation (appearance, spoilage, odour) and microbiological analyses (mesophiles and Enterobacteriaceae) were carried out on days 0, 6,11 and 14.

2.2. Gases determination

Carbon dioxide and oxygen were determined using an O_2 and CO_2 headspace gas analyzer Checkmate model 9900 (PBI-Dansensor, Ringsted, Denmark). Samples were automatically extracted with a syringe.

2.3. Texture

Texture was determined by measuring the maximum force necessary to cut three asparagus with the shear press, at 13 cm from the tip, using a 1-mm blade adapted to an Instron Universal Testing Machine (Instron Model 1140, Instron Ltd, High Wycombe, UK) with a displacement speed of 20 cm/min. The maximum force was calculated in Newtons (N)

2.4. pH and acidity

For pH and acidity determination, 10 g of asparagus were blended with 100 ml of distilled water. The pH of the homogenized sample was measured with a Crison model 2002 pH meter (Crison Instruments, Barcelona, Spain) and acidity was evaluated by adding NaOH 0.1 N until pH 8.1 was reached and expressed as citric acid percentage (Kramer & Twigg, 1973).

2.5. Sensorial evaluation of fresh asparagus

The samples were evaluated for their appearance, spoilage and odour. The visual appearance of the spears was evaluated taking into account the colour of the apical section, the colour of the entire asparagus and the dark blotch incidence. Spoilage incidence was determined by the number of spears affected by spoilage in the three trays evaluated each sampling day. The presence of off-odours when the packages were opened was evaluated.

2.6. Microbiological analysis

Twenty-five grams of asparagus were aseptically weighed and homogenized in a Stomacher (IUL, Barcelona, Spain) for 2 min with 225 ml of sterile peptone water (Oxoid). Further decimal dilutions were made with the same diluent. The total number of mesophilic microorganisms was determined on plate count agar (PCA, Merck) following the pour plate method, incubating at 30 °C for 72 h (ICMSF, 1978). Enterobacteriaceae were determined on violet red bile glucose agar (Difco, Detroit, Mich., USA), the plates were overlayed before incubation at 37 °C for 18–24 h (ICMSF, 1978).

2.7. Sensorial analysis of cooked asparagus

The samples were sensorial analysed after boiling for 20 min in tap water with 1% (w/v) sodium chloride. Samples were evaluated for overall acceptability (appearance, taste and texture) by a panel of 10 judges who were regular consumers of asparagus. A structured hedonic scale, with numerical scores from: 9 (I like it very much) to 1 (I dislike it very much), was used (Anzaldúa-Morales, 1994). A score of 5 was considered the borderline of acceptability.

2.8. Statistical analysis

The experimental design was a factorial experiment (2 × 2 × 4) with 3 repetitions, in which the factors considered were the type of film, the temperature and the storage period. Analysis of variance was performed for gases, cutting force, pH, acidity and microbial counts, using the SYSTAT program for Windows, Statistics version 7.0 (1992, Evanston, Ill. U.S.A.). The comparison of means was performed using the LSD for $p \leq 0.05$ (Dagnelie, 1975). Plate count data were converted to logarithms prior to their statistical treatment. Sensorial results of cooked asparagus were treated by analysis of variance for one factor. The factor treatment corresponded to groups evaluated on days 6 and 11 with 10 repetitions (scores given by the 10 judges).