Preliminary Study on Qualitative and Microbiological Changes in Fresh-Cut Broccoli Raab during Cold Storage

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Abstract

Changes in atmosphere composition and colour, tissue browning, decay, microbial viable cell count and sensorial attributes of fresh cut broccoli raab were studied. Broccoli raab heads and young leaves were placed in polystyrene trays, covered with polyvinyl chloride (PVC) and polyamide/polyethylene (PA/PE) laminated films and then stored under self controlled atmosphere (SCA) at 4°C for 16 d. Viable cell counts of packaged fresh-cut vegetables were lower than the legal limit for safe consumption until the 12th day of storage in both PA/PE and PVC covered trays. However, after 8 and 12 d of storage, microbial counts of broccoli raab stored in PVC were approx. 2 log cfu g^{-1} higher than those in PA/PE. Browning was only significant in samples packaged in PA/PE, probably due to high CO_2 concentration inside the package. The results showed that PVC packaging was the best solution for fresh broccoli raab heads and young leaves stored at 4°C in SCA, leading to a shelf life of 12 d compared to 7 d if vegetables were stored in PA/PE.

INTRODUCTION

Leafy brassicas are widely used for fresh-cut pre-packaged salads. Broccoli raab (*Brassica rapa* L.), also called turnip top or rapini, is largely cultivated in southern Italy. The edible parts are the green-immature inflorescences and the stem with tender leaves. Recently, the interest in this crop has been increasing in Europe. Moreover, consumption may be substantially enhanced by a fresh-cut product that offers consumers high nutritional value, convenience and flavour while still maintaining their freshness (Lamikanra, 2002).

Broccoli raab are highly perishable, shelf-life in air at 20°C is limited to 2-3 d. As the vegetable deteriorates buds become yellow, tissue becomes flaccid and cell necrosis develops during advanced senescence (King and Morris, 1994). In addition to changes in metabolic activities, major parts of decay of fresh cut products can be ascribed to microbial loads (Ragaert et al., 2007).

The aim of this study was to evaluate the microbiological and qualitative changes during the cold storage of fresh-cut broccoli raab packaged with polyvinyl chloride (PVC) and polyamide/polyethylene (PA/PE) laminated film and stored at 4°C under self controlled atmosphere (SCA).

MATERIALS AND METHODS

Broccoli raab heads and young leaves, not longer than 10 cm, were cut from the stem, placed in polystyrene trays and packaged using two different plastic bags: highly permeable polyvinyl chloride (PVC, 10 µm thickness) and low permeable polyamide/polyethylene (PA/PE, ratio 20/70 - 90 µm thickness) laminated films. Each package containing about 250 g of product was prepared in 3 replicates. The packages were stored under Self Controlled Atmosphere (SCA) at 4°C for 20 d. Changes in atmosphere composition, tissue browning, microbial load and sensorial attributes were evaluated after 0, 4, 8, 12 and 16 d of storage.

Changes in atmospheric composition were only analysed on samples stored in PA/PE packages. Air (1 ml) was taken from the package headspace and concentrations of O_2 and CO_2 were monitored (isothermally at 100°C) using a gas chromatograph (P200

micro GC, Agilent Technologies, Palo Alto, USA), with MS5A column, TCD detector, and helium as carrier gas. Data analysis was performed with SOPRANE (release 2.1.0, S.R.A. Instruments Italia, Cernusco sul Naviglio, Italy). On 3 random points on cut broccoli raab leaves colour was determined in the reflectance mode by a colorimeter (CR-400, Konica Minolta, Tokyo, Japan) and expressed as L* (luminosity), a* (green-red), and b* (blue-yellow) values.

Two microbial population kinetics, total mesophilic bacteria (Plate Count Agar, 30°C for 24h), *Enterobacteriaceae* (Violet Red Bile Dextrose Agar, 37°C for 24h) were evaluated during the 16 d of cold storage. To prevent yeast growth cycloheximide (150 mg L^{-1}) was added to the PCA. For analysis of microbial populations approx. 25 g of broccoli raab were aseptically and separately transferred to a stomacher bag containing 9 parts (w/w) of sterile saline solution (0.9% NaCl) and homogenised in a stomacher (BagMixer, Interscience, St Nom, France) for 3 min. Appropriate dilutions of broccoli raab samples were plated in triplicate on specific media for different viable counts.

For evaluation of packaging effects on the sensorial attributes of fresh-cut broccoli raab during the storage, a score for general appearance and odour evaluation was given according to Amodio et al. (2007). The scale consisted of five quality classes (5 = excellent, no defects, typical odour, and 1 = inedible, odour of mouldiness). A score of 3 was considered as the limit of marketability and a score of 2 as the limit of edibility.

Analysis of variance (ANOVA) was performed on raw data to detect statistical difference between packaging treatments for each quality attribute. Significantly different means were separated using the SNK test.

RESULTS AND DISCUSSION

During storage, CO_2 concentrations increased reaching the higher value (approx. 28%) after 16 d (Table 1), while O_2 concentrations rapidly decreased due to the low film permeability and high broccoli raab respiration. The composition of the package atmosphere influenced broccoli raab appearance and microbial quality. Evaluation of appearance and odour of the produce revealed significant differences between packaging treatments (Table 2). Broccoli raab stored in PVC film showed a mean score of 3.7, meaning a good appearance with a slight yellowness. Moreover, samples stored in PA/PE film presented a lower score (2.4) due to symptoms of browning and a moderate odour of sulphurated substances. In addition samples stored in PA/PE and in PVC film remained marketable until the 6^{th} and 12^{th} day in cold storage, respectively (Fig. 2). Colour analysis confirmed these data; in particular, significant difference ($P<0.05$) were detected between treatments for a* and b* parameters (Table 2). Samples stored in PA/PE film showed a slight browning measured by increased a* value, while in samples stored in PVC a yellowness was indicated by increased b* parameter.

According to Ragaert et al. (2007) the total microbial load on fresh cut broccoli raab packaged both in PVC and PA/PE bags, was lower than the legal limit for safe consumption until the end of storage (Fig. 1a). In particular, in the samples stored in PA/PE, the total aerobic bacteria viable cell count decreased from the initial load of 7 to 4 log cfu g^{-1} until the 12^{th} day; then it increased to about 5.5 log cfu g^{-1}. The reduction and following increasing of microbial viable cell counts of broccoli raab packaged in PVC bags showed less marked variations.

The growth kinetic of *Enterobacteriaceae* (Fig. 1b) rose from 3 to 5 log cfu g^{-1} in PVC samples until the 8^{th} day; after 12 and 16 d of storage it was about 4 and 5.5 log cfu g^{-1}, respectively. In PA/PE bags the *Enterobacteriaceae* load was 4.9 log cfu g^{-1} at the 4^{th} day; it progressively decreased to 2.5 log cfu g^{-1} and reached the value of 4.3 at the end of storage.

High CO_2 concentration effectively retarded microbial growth in PA/PE samples, but it caused browning and off-odours that made broccoli raab unmarketable after a week of storage. Similar injuries associated with CO_2 concentration have been reported by O'Hare et al. (2000). Packaged in PVC broccoli raab showed pronounced yellowness due to advanced senescence at the end of storage.

The results of this study indicated that broccoli raab may be processed as fresh-cut vegetable (Fig. 3) and to extend its the shelf-life in PVC bags up to 12 d. In contrast, storage in PA/PE bags is limited to approx. one week even if both total aerobic bacteria and *Enterobacteriaceae* viable cell counts were always higher in broccoli raab stored in PVC. The results also indicate that metabolic activitiy of broccoli raab tissue has a stronger effect on shelf-life than total mesophilic and *Enterobacteriaceae* loads.

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Tables

Table 1. Composition of the atmosphere in PA/PE packages (means ± SD).

Days	O_2 (%)	CO_2 (%)
0	21 ± 0.01	0.03 ± 0.01
4	4.0 ± 0.01	10.0 ± 0.02
8	1.2 ± 0.02	14.4 ± 0.08
12	1.3 ± 0.08	19.4 ± 0.06
16	1.2 ± 0.08	28.8 ± 0.09

Table 2. Effect of packaging on fresh-cut broccoli raab qualitative traits; mean values for each treatment followed by the same letter are not significantly different, $*P<0.05$.

Attributes	Packaging	
	PA/PE	PVC
a* (green-red)	-15.8 a	-17.1 b
b* (blue-yellow)	31.3 b	32.9 a
Appearance and odour score	2.4 b	3.7 a

Figures

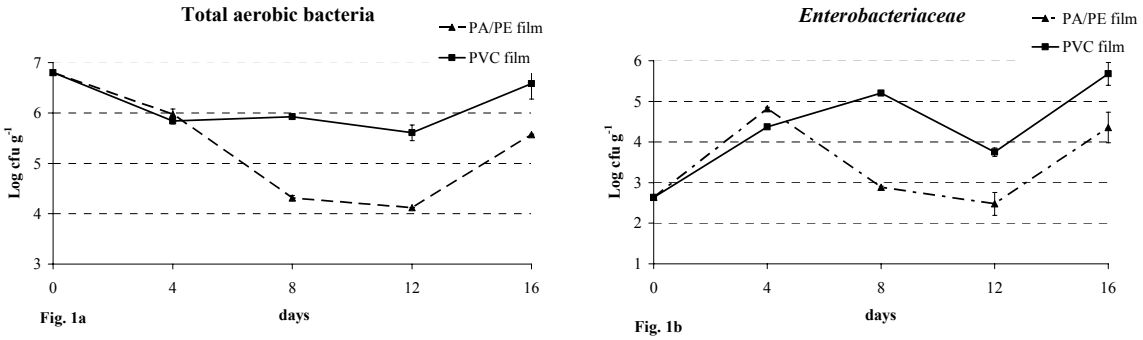

Fig. 1. Growth dynamics of total aerobic bacteria (a) and *Enterobacteriaceae* (b) from fresh cut broccoli raab during cold storage in PA/PE and PVC packages (means ± SD).

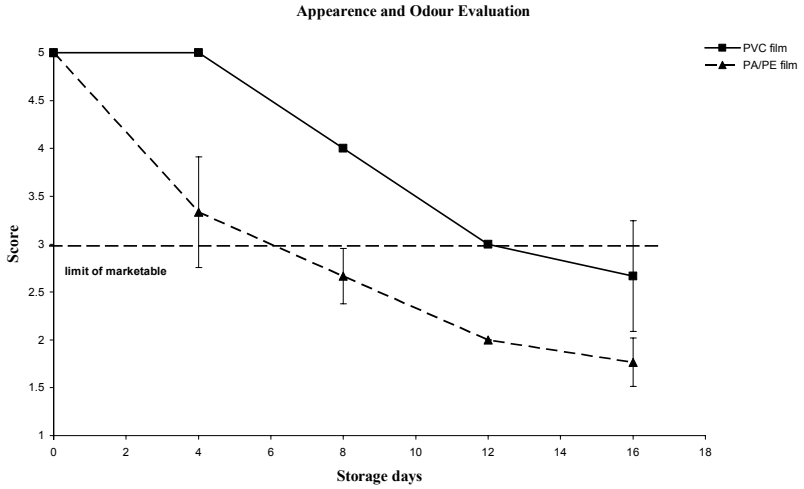

Fig. 2. Appearance and odour evaluation.

Fig. 3. Fresh-cut broccoli raab.