Modified atmosphere package for apple 'Bravo de Esmolfe'

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Abstract

Apple 'Bravo de Esmolfe' original from the parish of 'Esmolfe' is cultivated in specific regions of Portugal. This cultivar of medium to low production requires very low temperatures, but it is extremely sensitive to frost. The aim of this work was to evaluate the influence of modified atmosphere on the quality of apple (cv. Bravo de Esmolfe) during cold storage. Apples packed in modified atmosphere lost less weight, presented better colour, and preserved better firmness than fruits stored in air.

Introduction

Apple 'Bravo de Esmolfe' original from the parish of 'Esmolfe' is cultivated in specific regions of the North of Portugal, council of Penalva do Castelo, growing in Mangualde, Viseu, Lamego, Moimenta da Beira, Covilhã, Belmonte and Fundão, all of them in the North of the country. The first apple tree must have appeared two hundred years ago in the village of Esmolfe and resulted naturally from a seed, this fact is responsible for its name *Bravo* (meaning *wild*). Due to its rare sensory characteristics it was cultivated more and more by the farmers being the variety produced in higher amount in this region in the middle of the XX century. The importance of this apple variety was recognized by classification of *Nomination of Protected Origin* [Denominação de Origem Protegida] (DOP).

This cultivar of medium to low production requires very low temperatures, but it is extremely sensitive to frost (Mendes, 2001). This apple variety differs from all other varieties mainly in flavour and aroma. Due to its unique organoleptic characteristics, it finds high preference among the consumers and its price can reach high values (Mendes, 2001).

'Bravo de Esmolfe' is harvested in the middle of September and its commercialization last no longer than May, being more intensive between December and February. The successful outcome of marketing trials suggests that the area planted could increase and this would require for recommendations for long-term storage.

Modified atmosphere packaging is a technological process successfully used with many fruit varieties, especially those of high commercial value. The modification of carbon dioxide and oxygen concentration in the atmosphere surrounding the product allows control of microbiological growth, respiration rate, enzymatic activity and oxidation (Brecht, 1995). Apples are known to benefit greatly from controlled atmosphere (CA) storage: an extensive literature exists regarding the effects of CA on the postharvest physiology and quality attributes of apples (Ben-Arie, Levine, Sonego, & Zutkhi, 1993; Chen, Varga, Mielke, & Drake, 1989; Drake, Eisele, & Waelti, 1993; Drake & Eisele, 1994; Lau, Meheriuk, & Olsen, 1983; Little, Faragher, & Taylor, 1982). Nevertheless, since there are differences in tolerance to elevated CO_2 among apple varieties (Kader, 1989), no recommended atmosphere composition exists to be applied to all apple varieties.

The aim of this work was to evaluate the influence of modified atmosphere on the quality of apple (cv. Bravo de Esmolfe) during cold storage. Apples were stored in air and modified atmosphere packages during 6.5 months at 4 °C and evaluated at different periods of storage.

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Material and methods

Fruits were harvested on September, 29, 1999 and stored at 2 °C and 85% relative humidity in air and MA packages during 6.5 months and evaluated at different periods of storage. Two different plastic films were used: perforated bags in order to allow normal atmosphere (NA), plastic 1, and plastic 2–polypropylene 100 μm, $\beta = 3.13$, $P_{CO_2} = 711$ ml/(m^2 d bar) and $P_{O_2} = 227$ ml/(m^2 d bar) at 2 °C (MA).

Eighteen bags from each storage condition were assayed for gas concentration, colour, water loss, pH, soluble solids content and total conductivity at different periods of storage.

Gas concentration inside the bags was analyzed by sampling from a silicone septum on the package. The carbon dioxide and oxygen concentrations in the atmosphere surrounding the product were measured by injection of 0.6 ml in a gas chromatograph (Shimadzu GC-14-A), equipped with a thermal conductivity detector (TCD) and connected to a 3 m × 0.32 cm column packed with 80/100 mesh Carbosieve S II (Supelco).

The injector and detector temperatures were set at 120 and 210 °C, respectively. The temperature of the column oven was programmed for 40 °C for 6 min and subsequently for 15 °C min^{-1} to 170° and hold for 5 min. Flow rate of the carrier gas, helium, was 30 ml/min and the bridge-current of the TCD was 140 mA.

Cut apple surface *colour* was measured by reflectance based on the Hunter system using a tristimulus reflectance colorimeter (Minolta CR-300, Ramsey, NJ, USA) calibrated with a white standard tile. The L^*, a^* and b^* parameters were registered and their numerical values were converted into hue angle ($H = \tan^{-1} b^*/a^*$) and chroma (chroma $= (a^{*2} + b^{*2})^{1/2}$) (Francis, 1980).

Water loss was determined by the weight measurement and the calculation of the loss per month.

Firmness was evaluated using a Universal Testing Machine (INSTRON 4500), as the maximum force (N) to the lateral radial surface of the apple. Each sample was punctured twice in opposite sides, using a puncture probe (8 mm diameter), at 15 mm/min cross-head speed and load was determined with a 100 N load cell (Kader, 1982).

The *pH* of the fruit was determined using a Crison MicropH 2002 potentiometer and a xerolyt electrode Ingold Lot 406–MG–DXK–57/25, calibrated at pH 4.0 and 7.0 (Rocha, Brochado, Kirby, & Morais, 1995).

Soluble solids content was determined individually for each of the replicates with a hand-held sugar refractometer model Atago-ATCI. Results were expressed as degree Brix (Rocha et al., 1995).

Total conductivity (%) was determined, by using a Crison GPL 31 conductimeter after 6.5 months of storage and 24 h of incubation at room temperature. The fruits were rinsed and the electrolytic conductance was determined on epicarp and flesh discs (1.3 cm^2 each). Five disks from each sample were placed in a flask with 15 ml of deionized water at 25 °C for 24 h and then the absolute conductance measured. Electrolytic conductivity readings of the solution were taken after 2, 4, 5, 6, 7 and 24 h as a measure of electrolytic leakage from the discs, using a Crison GPL 31 conductimeter. Total conductivity was obtained after keeping the flasks in an oven at 90 °C for 15 min and the electrolytic yield obtained was taken as 100%. All leakage data were expressed as a percentage of total electrolyte readings (King & Ludford, 1983).

Results and discussion

The concentration of gases inside the MA bags attained an equilibrium after two days of storage. During 130 days of storage at 2 °C these concentrations were 13.9% O_2 and 2.3% CO_2. After 130 days the concentration of O_2 decreased to 10% and the concentration of CO_2 increased to 5%. These values were maintained until 200 days of storage.

Apples packed in MA lost less weight: weight loss less than 2% after 6.5 months, while under normal atmosphere the water loss was about 7% after the same period of time. Water loss can be one of the main causes of deterioration, since it not only results in direct quantitative losses (loss of salable weight), but also causes losses in appearance (due to wilting and shriveling), texture (softening, flaccidity, loss of crispness and juiciness), and nutritional quality. MA does not directly influence the rate of water loss, but the need for a gas-tight environment for MA storage and transport often results in significantly higher relative humidity around the commodity and consequently reduced water loss compared to air storage (Kader, 1986).

Apples stored in MA packs presented better colour than fruits stored in air. After 6.5 months at 2 °C the former presented higher L^* and hue values and lower a^* value (Fig. 1) than after 4.5 months of storage. This might be due to the change in the composition of the modified atmosphere, slightly improving the colour of the samples.

Apples from MA storage after 6.5 months at 2 °C were firmer than fruits from air (Fig. 2). This was due to the beneficial effect of MA storage. Drake (1993) found that 'Delicious' and 'Jonagold' apples were firmer after 60 days of CA storage than fruit from air storage. MA conditions have been reported to delay fruit ripening and softening (Kader, 1986). No significant differences were detected in the pH and soluble solids content of apples stored in air and MA after 6.5 months at 2 °C (Figs. 3 and 4). This means that the modified atmosphere had no effect on these parameters. Through the maintenance of sugars and acids, long term MA storage

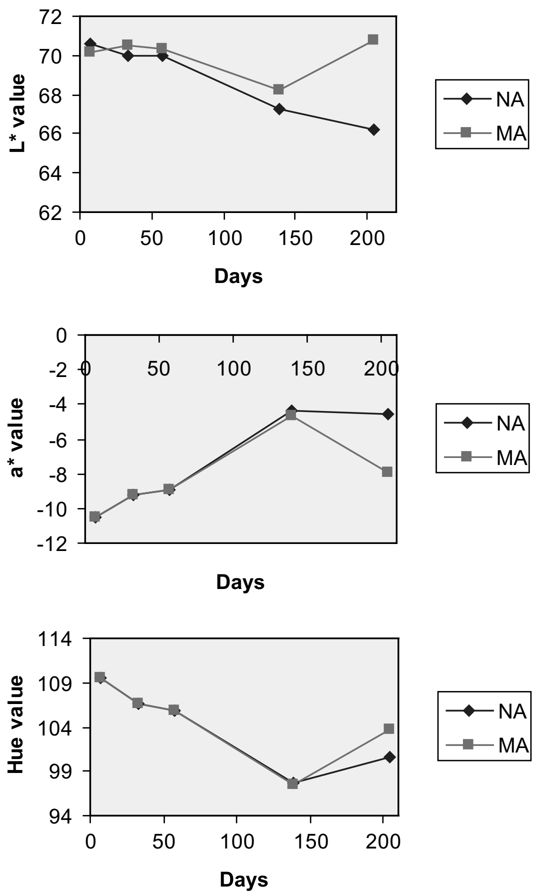

Fig. 1. Colour parameters L^*, a^* and hue of apple 'Bravo de Esmolfe' stored in air and MA.

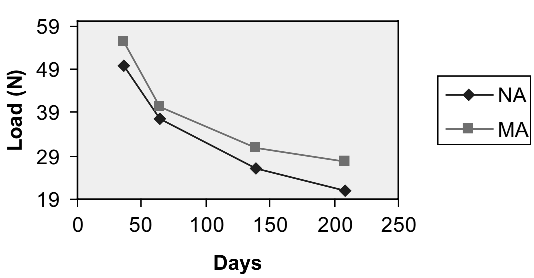

Fig. 2. Firmness (load) of apple 'Bravo de Esmolfe' stored in air and MA.

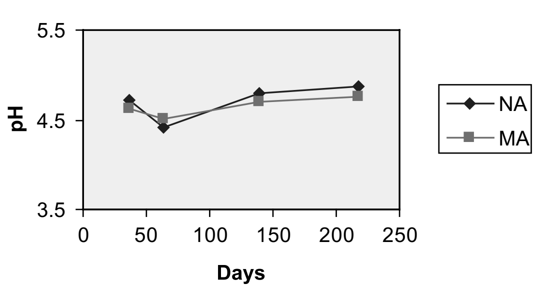

Fig. 3. pH value of apple 'Bravo de Esmolfe' stored in air and MA.

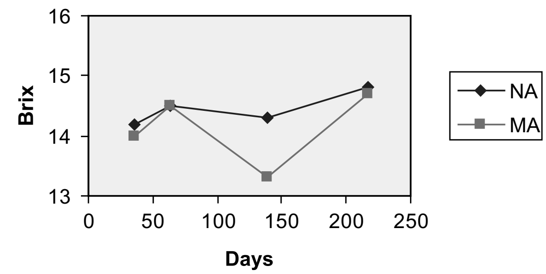

Fig. 4. Soluble solids content (° Brix) of apple 'Bravo de Esmolfe' stored in air and MA.

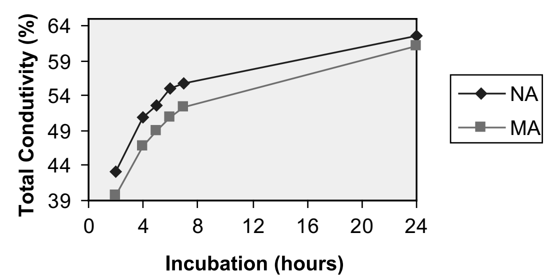

Fig. 5. Total conductivity (%) of the epidermis of apple 'Bravo de Esmolfe' stored in air and MA.

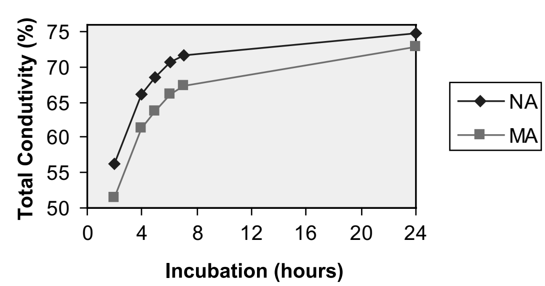

Fig. 6. Total conductivity (%) of the flesh of apple 'Bravo de Esmolfe' stored in air and MA.

maintains dessert quality of apples (Rocha, Brochado, & Morais, 1998).

After 6.5 months of storage and 24 h of incubation at room temperature apples from MA storage presented lower conductivity (%) than fruits from air in epidermis and flesh (Figs. 5 and 6), meaning a lower electrolyte leakage which is a good aspect showing the advantage of MA storage.

Conclusions

Results of total conductivity and firmness suggest some effect of MA storage on reducing membrane permeability of fruits with a decreasing degradation of cellular walls.

Apples packed in modified atmosphere lost less weight, presented better colour, and preserved better firmness than fruits stored in air.

There is a potential for improving the quality and extending the market life of 'Bravo de Esmolfe' apples by MA. This requires a detailed understanding of the behaviour (particularly respiration rate), optimum and tolerance limits for gases and relative humidity. Additional work is necessary in order to optimize the modified atmosphere package to uniformly preserve quality parameters of apple 'Bravo de Esmolfe'.

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