Effects of modified atmosphere packaging on quality parameters of minimally processed table grapes during cold storage

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Abstract: 'Vittoria' and 'Red Globe' table grapes were packed in microperforated polypropylene films (passive MAP) and non-perforated polyethylene (active MAP: 1) 20% CO_2 + air; 2) 5% O_2 + 15% CO_2 + N) and stored at 5 °C for 28 days. Microperforated polypropylene packages had the highest postharvest performance in both cultivars until 14 days of cold storage, with reduced weight losses, rachis and berry decay. Total soluble solids content slightly increased in non-perforated polyethylene boxes as a consequence of the higher weight losses, particularly in active MAP with 5% O_2 + 15% CO_2 + N, while no significant differences were found for titratable acidity. Non-perforated polyethylene packages showed excessively high CO_2 concentrations (30-60%) in headspace gas composition, causing berry and rachis decay. The highest post harvest performances in terms of weight losses, Total soluble solids, titratable acidity, crunchiness, juiciness and berry decay were found with micro-perforated polypropylene packages after 14 d of 5 °C cold storage, and 6 days of shelf-life (15-18°C).

1. Introduction

In recent years, consumer demand for ready-to-eat fruits and vegetable products, has increased considerably due to product added value and easy consumption. A major challenge facing this industry is maintaining and preserving the quality of minimally processed produce because the physical damage caused by preparation accelerates the metabolism with associated increases in certain biochemical reactions responsible for quality loss (Sabir *et al.*, 2011).

Table grape is a non-climacteric fruit with a low rate of physiological activity that is very sensitive to water loss and fungal infection (*Botrytis cinerea*) during postharvest handling and cold storage. Gray mold is the most aggressive post harvest disease because of its ability to develop at low temperatures. For this reason, it is standard practice to fumigate table grapes with sulfur dioxide (SO_2) immediately after packing (Crisosto and Mitchell, 2002). However, sulphite residue is an important consumer problem. To avoid it, different technologies have been developed such as controlled atmosphere (CA), storage with high CO_2 (15-25%), and hot water and ethanol (Crisosto *et al.*, 2002; Karabulut *et al.*, 2004), although injuries occur, like rachis browning and off-flavors.

One of the most effective technologies in terms of quality commodity preservation is the combination of modified atmosphere and packaging (MAP) that protects from water loss and browning, and reduces chilling injury symptoms (Kader *et al.*, 1989). Martinez-Romero *et al.* (2003) showed that the use of MAP maintained table grape berry quality.

The aim of the present work was to study the effects of MAP on quality parameters of minimally processed white 'Vittoria' and red 'Red Globe' table grape cultivars during 28 days of cold storage.

2. Materials and Methods

Plant material

White and red table grapes (cv. Vittoria and cv. Red Globe) were harvested from a commercial vineyard, located in Mazzarrone Italy (37° 05' N, 14° 34' E, 128 m asl, CT). The vineyard has a row spacing of 2.8 m × 2.8 m (with 1275 plants/ha) with "tendone" training system, covered with net.

White 'Vittoria' (July) and red 'Red Globe' (September) table grapes were hand-picked at the commercially ripe stage (≥12.5°Brix), suitable for the fresh fruit market. Immediately after harvest, table grape quality parameters were analyzed on three clusters per cultivar.

Sample preparation and packaging

After harvest, 'Vittoria' and 'Red Globe' clusters were immediately transported to the laboratory and selected on

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the basis of uniform size, color, firmness, lack of diseases, health and greenish rachises. Table grape clusters were then cut with sanitized scissors to obtain a 200 g cluster. The samples were sterilized with sodium hypochlorite solution (150 ppm active chlorine) and were irradiated with ultraviolet-C (UV-C) to control microbial spoilage.

After washing, each 200 g cluster sample was packaged in a 15×8 cm rigid polypropylene retail box and sealed with two different films: microperforated polypropylene and non-microperforated polyethylene. The boxes sealed with microperforated polypropylene film were packaged in air (passive MAP), while, the boxes sealed with non-microperforated polyethylene film were packaged under two different initial headspace gas compositions (active MAP: 1) 20% CO_2 + air; 2) 5% O_2 + 15% CO_2 + N). The sealed boxes were then stored at 5°C with a relative humidity of 90% for 28 days, with quality evaluation performed on days 0, 7, 14, 21, and 28, after the shelf-life (5 days at 15-18°C).

Quality parameters: firmness, soluble solids, titratable acidity and decay

For each treatment, 12 randomly chosen boxes, were taken for shelf life at each sampling date (7, 14, 21, 28 days) and analyzed for weight loss, soluble solid content (SSC), pH, titratable acidity (TA) and decay. Berry weight loss was calculated as a percentage of its fresh weight (at the beginning of each shelf life). Total soluble solids (TSS) were determined by digital refractometer (Palette PR-32, Atago Co., Ltd) and titratable acidity (TA) by titration of 10 ml homogenized berry flesh juice with 0.1 N NaOH to an endpoint of pH 8.1 and expressed as the percentage of tartaric acid. (mod. S compact titrator, Crison Instruments.

Headspace gas composition

O_2 and CO_2 contents of the packages were measured using an O_2 and CO_2 portable analyzer (Checkpoint, Dansensor Italia, Segrate, Milano, Italy) during each shelf-life, after 7, 14, 21, 28 days at 5°C.

Statistical analysis

Data were submitted to one-way analysis of variance (ANOVA) and means were separated with Tukey's test at P≤0.05. The statistical analysis was carried out using Systat 10 (Systat, USA).

3. Results and Discussion

Weight loss (Fig. 1A) of 'Red Globe' packaged with non-microperforated polyethylene sealed boxes (active MAP: 20% CO_2+air (PET1); 5% O_2+15% CO_2+N (PET2) increased sharply during storage, reaching values lower (8% and 14 % respectively) than those measured at the beginning of the shelf-life. Weight losses of 'Red Globe' grape packaged with microperforated polypropylene box-

es (passive MAP (PP) were significantly lower than PET1 and PET2, with weight losses of 4% during shelf-life.

TSS content did not significantly change ($P<0.05$) in 'Red Globe' table grapes wrapped with PP (passive MAP) at the end of the shelf-life (Fig. 1B), while a significant increase ($P<0.05$) in TSS was found in table grapes packaged in both active PET1 and PET2 (active MAP), with an increase of 4% and 6% at the end of the shelf-life (Fig. 1B).

Non-perforated polyethylene packages (PET1 and PET2) showed excessively high CO_2 concentrations (from 30 to 60%) in headspace gas composition of 'Red Globe' and 'Vittoria' table grapes, causing berry and rachis decay (Fig. 1C, 2C).

Non-microperforated polyethylene sealed boxes of both cultivars (PET and PET2), showed a similar trend in
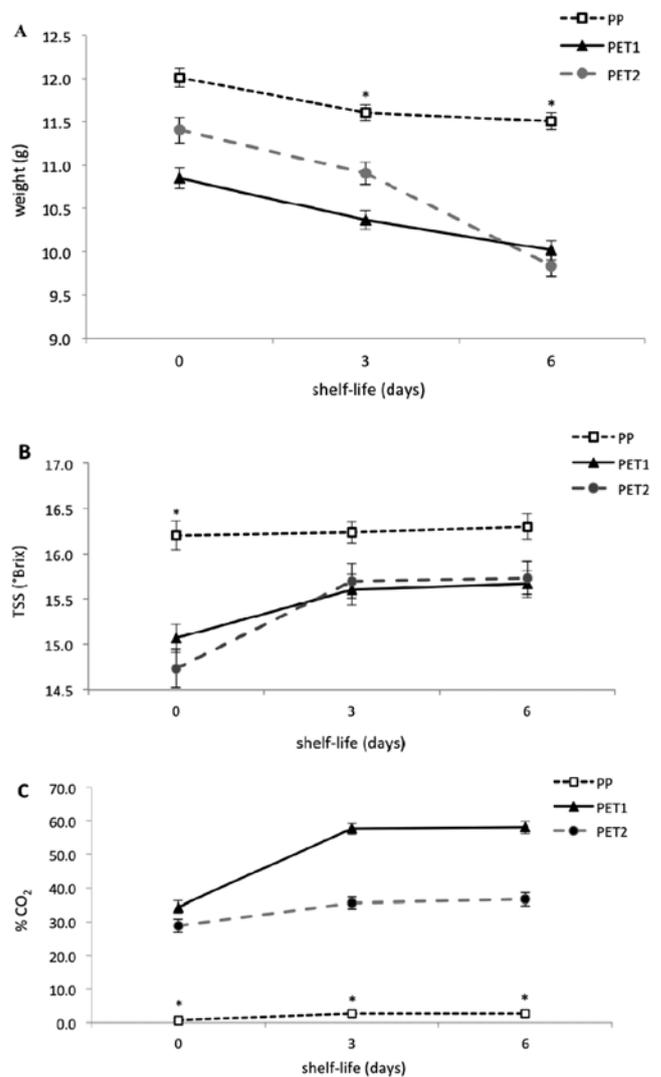

Fig. 1 - Changes in weight loss (A), soluble solid content (B) and headspace CO_2 concentration (C) of minimally processed 'Red Globe' grape berries during shelf life after 14 days of cold storage (5°C): microperforated polypropylene packaging in air (PP); non-microperforated polyethylene packaging in 20% CO_2+air (PET1); non-microperforated polyethylene packaging in 5% O_2+15% CO_2+N (PET2). Data are mean±SE. * indicate significant differences for values ($P≤0.05$).

terms of weight loss. Indeed, berries had 9% and 14% decrease of weight loss during the shelf-life while PP table grape boxes showed a significantly lower decrease (4%) compared to PET1 and PET2. (Fig. 2A).

TSS of PET1 and PET2 'Vittoria' berries were significantly higher ($P<0.05$) than those of PP treatments, with an increase of 5% and 8% respectively at the end of the shelf-life (Fig. 2B). A good visual aspect and no off-flavor were detected until 21 days of cold storage in 'Vittoria' PP table grapes (data not shown). Packaging did not affect TA in either of the cultivars.

Microperforated polypropylene packages (PP) had the highest postharvest performance in both cultivars until 14 days of cold storage, also in terms of rachis and berry decay.
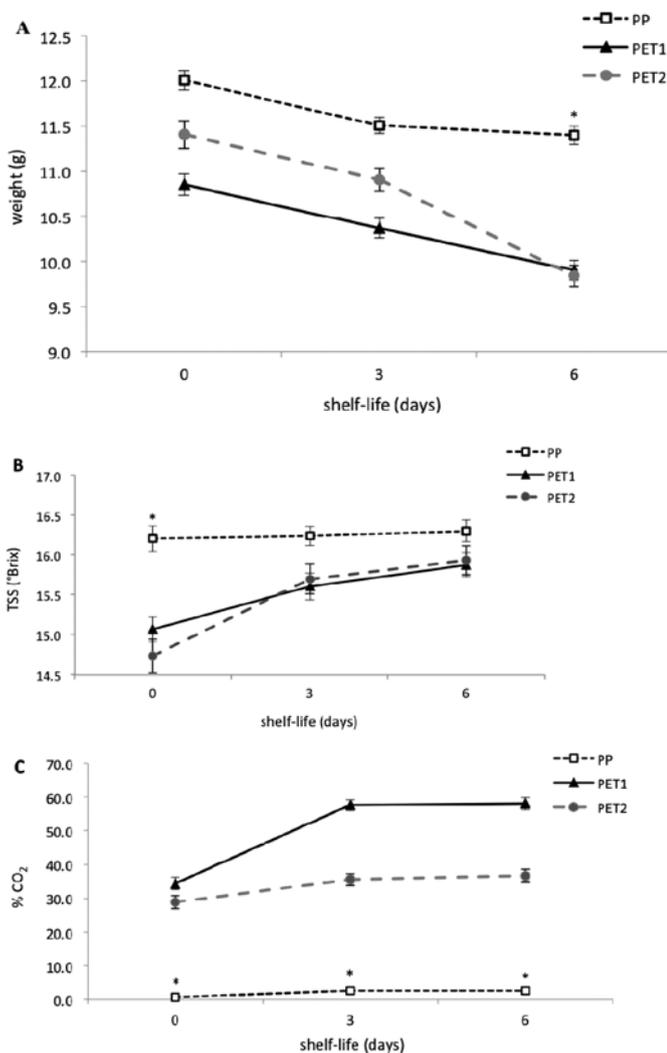

Fig. 2 - Changes in weight loss (A), soluble solid content (B) and headspace CO_2 concentration (C) of minimally processed 'Vittoria' grape berries during shelf life after 14 days of cold storage (5°C): microperforated polypropylene packaging in air (PP); non-microperforated polyethylene packaging in 20% CO_2 + air (PET1); non-microperforated polyethylene packaging in 5% O_2+15% CO_2+N (PET2). Data are mean±SE. * indicate significant differences for values (P≤0.05).

4. Conclusions

'Vittoria' and Red Globe' grapes showed the best postharvest performances in terms of weight losses, TSS, TA, crunchiness, juiciness and berry decay when packed with micro-perforated polypropylene packages after 14 days of 5°C cold storage and 6 days of shelf-life (15-18°C). This study has demonstrated that active MAP (PET1 and PET2) did not affect the postharvest performances of minimally processed table grapes. As Costa *et al*. (2011) reported, the conditions created in the package to modify the initial headspace composition probably compromised the mass loss and the sensory acceptability of the fresh produce.

'Vittoria' berries and rachises from PP boxes remained healthy and green, even after 21 days of 5°C storage, which could be useful for consumers interested in ready-to-eat products.

Acknowledgements

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