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Storability, shelf-life and quality assurance of sugar snap peas (cv. super sugar snap) using modified atmosphere packaging

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ABSTRACT

This investigation was aimed at selecting the most suitable package to maintain quality of sugar snap peas pods. The effectiveness of five types of polypropylene packages: highly perforated (HPPP), non-perforated (NPPP) and micro-perforated with 6, 12 and 24 holes (MPPP6, MPPP12 and MPPP24) on storability of pods was studied during cold storage at 0 °C with 90–95% RH for 7, 14, 21 days and simulating shelf-life conditions at10 °C with 80–85% RH for 2 or 4 days after 21 days at 0 °C. O_2 and CO_2 concentrations, weight loss, visual quality, off odors, decay, color, firmness, crispness, taste, total chlorophyll, vitamin C, SSC, and total sugar contents were measured. Results revealed that O_2 decreased and CO_2 increased slowly inside MPPP6, MPPP12 and MPPP24 bags, however, the reduction in O_2 and the increments in CO_2 in NPPP bags were very sharp and accompanied with high levels of off odors. HPPP had the highest weight loss compared with other bags. MPPP12 bags maintained quality during storage and simulated shelf-life, in terms of higher scores for visual quality, firmness, crispness and taste as well as highest contents of chlorophyll, vitamin C and sugars. NPPP bags had the worst values for quality. At the end of storage and shelf-life, an increment in h^* was observed in samples stored in MPPP6, MPPP12 and MPPP24 bags (more green color) in comparison with those in NPPP bags.

1. Introduction

Sugar snap peas (*Pisum sativum* L. var. *saccharatum*) are a new type of pea in Egypt, sown for export. They play an important role in human nutrition as a cheap source of protein, carbohydrates, vitamins, minerals and other nutrients. Edible-podded peas are harvested before physiological maturity is reached to retain their quality. Shortly after harvest, loss of sweetness and crispness, de-greening and the development of mealiness may decrease quality. Kader (1992) stated that peas are a highly perishable immature commodity that can be cooled and stored at temperatures near 0 °C to extend shelf-life. They have a very high respiration rate and are classified as a non-climacteric commodity. All types of peas can be stored for 1–2 weeks at 0 °C and 95–98% RH (Suslow and Cantwell, 1998).

The benefits of modified atmosphere packaging (MAP) are in extending shelf-life of products to meet market demand through reduction of metabolic activities and pathological deterioration. MAP vastly improves moisture retention by maintaining a higher RH around the fruit inside the sealed package, with an influence on preserving quality (Mangaraj et al., 2012). Passive modified atmosphere packaging is a technology that can be employed through the use of polymeric films with different numbers and dimensions of microperforations.

Storability and shelf-life, as well as quality of fruit and vegetables, are affected by type, thickness and perforation of films used in MAP (Serrano et al., 2006; Simon et al., 2008; Jia et al., 2009; Simon and Gonzalez-Fandos, 2011; Selcuk and Erkan, 2014). Serrano et al. (2006) found that broccoli packaged in micro-perforated polypropylene film had prolonged storability up to 28 days with high quality attributes and health-promoting compounds. A micro-perforated polyethylene film with 2 holes extended shelf-life and reduced postharvest deterioration of broccoli florets stored at 4 and 20 °C (Jia et al., 2009). Micro-perforated polypropylene films with 7 and 9 holes (90 μm) maintained strawberry quality during cold storage (Kartal et al., 2012). Packages with perforated areas of 1.57, 3.14 and 4.71 mm^2 can be used to preserve strawberry quality for 10 days at 2 °C (Sanz et al., 2002). Also, Almenar et al. (2007) reported that micro-perforated films with one and three perforations maintained the chemical, physical and sensory qualities of strawberries.

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Little information is available on passive modified atmosphere packaging of sugar snap peas. Sugar snap peas are exported from Egypt in highly perforated polypropylene traditional bags. This bag maintains visual quality for a maximum of 1–2 weeks. So, the peas are exported by air, which is very expensive.

The main objective of the present investigation was to evaluate the influence of passive MAP by using perforated polypropylene (control), non-perforated polypropylene and three new micro-perforated polypropylene films with 6, 12 and 24 holes, on the changes in several parameters related to sugar snap pea quality during cold storage and shelf-life. A further aim of this work was to reduce the transportation costs by using sea freight instead of air through a prolonged storage period.

2. Materials and methods

2.1. Plant materials and packaging treatments

Sugar snap peas (*P. sativum* L. var. *saccharatum* cv. 'super sugar snap') was planted in winter of 2011–2012 (from 2nd October to 5th March) at the Experimental Research Farm, Faculty of Agriculture, Suez Canal University, Ismailia Governorate, Egypt, to produce the pods of sugar snap peas.

Fresh pods were harvested by hand at the appropriate stage of maturity according to El-Seifi et al. (2014), on February 9, 2012 and transported to the laboratory of the Vegetable Handling Research Department, Horticulture Research Institute, ARC, Ministry of Agriculture, Egypt within 3 h. Pods were inspected and sound pods were held for 12 h at 0–2 °C and 90–95% RH, then the tops and tail of the pods were cut, and the pods sorted and graded according to export criteria prior to packaging (Suslow and Cantwell, 1998).

Fresh pods (250 g) were packed into five different types of polypropylene bags and sealed, with overall bags dimensions of 17 × 15 cm. Highly perforated bags (HPPP; obtained from El-Huda Company, Ismailia, Egypt), were 30 μm in thickness and with 1800 holes (1000 μm in diameter), commonly used for export in Egypt. The other bags (45 μm in thickness with 550 μm hole diameters) (obtained from ICOPACK Company, 6th of October, Giza, Egypt) were non-perforated bags (NPPP), micro-perforated bags with 6 holes (MPPP6), 12 holes (MPPP12) and 24 holes (MPPP24). Micro-holes were made in the bags using a 550 μm diameter cold needle (Watkins and Thompson, 1992).

The bags were placed in 5 kg carton boxes (26 W × 40 L × 12 H) cm and stored at 0 ± 1 °C, with 90–95% RH for 21 days. After 7, 14 and 21 days of storage, 6 bags (a replicate) from each treatment were transferred to an evaluation room. To simulate commercial storage and marketing, 12 bags after 21 days at 0 °C were kept sealed for 2 and 4 additional days (6 bags for each period) at 10 °C and 80–85% RH, then transferred to the evaluation room for the same assessment.

2.2. O_2 and CO_2 concentrations

The O_2 and CO_2 concentrations inside bag headspace during storage were analyzed using a DualTrak Model 902D gas analyzer (Quantek Instruments, USA) before opening. The headspace atmosphere within the 6 removal bags from each storage period was sampled using a syringe inserted through a septum.

2.3. Weight loss, visual quality, decay and color

All bags were weighed at zero time and at the end of each storage period and at subsequent shelf-life, 6 bags were reweighed. The weight loss was determined and expressed as percent loss from initial weight.

A panel of five trained judges (members of Vegetable Handling Research Department, Horticulture Research Institute, Agricultural Research Center, Egypt) evaluated the visual quality of all pods from each bag at the end of each storage period and subsequent shelf-life. Visual appearance was scored on a 9 to 1 scale, where 9 = excellent and fresh appearance, 7 = good, 5 = fair (limited marketability), 3 = poor and 1 = unusable, according to Jimenez et al. (1998). Pod surface color was evaluated on 6 pods from each bag using a Hunter colorimeter (Hunter Instrument DP-9000, Japan) which measures L^*, a^*, b^*, C^* and h^*. Higher positive hue values indicate green color. A color wheel subtends 360°, with red–purple traditionally placed at the far right (or at an angle of 0°); yellow, bluish–green, and blue follow counterclockwise at 90°, 180°, and 270°, respectively as reported by McGuire (1992).

2.4. Firmness, crispness, taste and off odors.

Firmness was evaluated by pressing the pod (six pods from each bag) between the thumb. A scale of 5–1 was used; 5 (firm and turgid), 4 (firm), 3 (moderately firm), 2 (limp and shriveled) and 1 (more limp and shriveled). Panelists rated sugar snap peas for crispness by bending to break the pod (six pods from each bag), on a scale of 5–1; 5 (fully typical), 4 (moderately full), 3 (moderate), 2 (slight) and 1 (none) (El-Bassiouny, 2003). Panelists rated the taste of six pods from each bag on a scale of 5–1, where 5 (fully typical), 4 (moderately full), 3 (moderate), 2 (slight) and 1 (none) (Kader et al., 1973). Off odors of 6 bags from each treatment was evaluated on a scale of 5–1, where 5 (severe), 4 (moderately severe), 3 (moderate), 2 (slight) and 1 (none) (Kasmire et al., 1974).

2.5. Total chlorophyll content

Total chlorophylls were extracted from fresh pods (0.5 g tissue from the center of the pods) by acetone (80%) and determined spectrophotometrically according to Lichenthaler and Wellburn (1983), and expressed as mg/100 g fresh weight.

2.6. Ascorbic acid content

10 g of pods tissue for each bag were ground thoroughly in a mortar with 40 ml of 4% oxalic acid solution. The mixture was poured into a 100 mL volumetric flask which was then filled with 4% oxalic acid solution and filtered through a filter paper (Whatman no. 1). Afterwards, 10 mL of supernatant were titrated to a permanent pink color by 0.1% 2,6-dichlorophenolindophenol. Ascorbic acid was calculated according to the titration volume of 2,6-dichlorophenolindophenol and expressed as mg/100 g fresh weight (Pearson, 1970).

2.7. Total sugars and soluble solids contents

5 g of fresh pods from each bag for each storage and subsequent shelf-life period were homogenized in 50 mL of 80% ethanol for 2 min and then refluxed for 30 min. The samples were centrifuged at 10,000 × *g* for 30 min. The residue was again subjected to ethanol extraction. The extracts were combined and alcohol was removed by evaporation. An aliquot was taken and then made up to 50 mL with distilled water. Total sugars were measured with phenol–sulfuric acid reagents spectrophotometrically at 480 nm according to Dubois et al. (1956). Soluble solids content (SSC) were measured by hand refractometer according to AOAC (1996) and expressed as %.