Postharvest Biology and Technology 86 (2013) 141–146

Contents lists available at SciVerse ScienceDirect

Postharvest Biology and Technology

journal homepage: www.elsevier.com/locate/postharvbio

Master packaging system for sweet persimmon applicable to produce supply chains

Mijin Jeong[a], Duck Soon An[a], Gwang-Hwan Ahn[b], Dong Sun Lee[a,*]

[a] Department of Food Science and Biotechnology, Kyungnam University, 449 Woryeong-dong, Masanhappo-gu, Changwon 631-701, South Korea
[b] Sweet Persimmon Research Institute, 262-1, Wodong-ri, Jinyoung-up, Gimhae 621-801, South Korea

ARTICLE INFO

Article history:
Received 7 September 2011
Accepted 15 June 2013

Keywords:
Master packaging
Bulk package
Persimmon
Micro-perforation
Display
Gas composition

ABSTRACT

Modified-atmosphere-packaged sweet persimmons experience significant quality loss due to temperature fluctuations in the food supply chain, which cause an imbalance between respiration and package gas permeation. This imbalance results in the package atmosphere deviating from the tolerable range. In this study, a master packaging system was designed to maintain a suitable modified atmosphere around the fruit during pre-sale chilled storage and during retail display to preserve freshness. A 50-μm-thick low-density polyethylene (LDPE) outer liner bag containing 46 individual fruit packages (30-μm-thick oriented polypropylene (OPP) film bag with a micro-perforation of about 60 μm) was placed within a corrugated paperboard box. Master packaging systems with and without the absorbent sachets were stored for 122 d at 0 °C and were periodically opened to remove and store the individual primary package units for 10 d at 10 °C to simulate retail display conditions. The master packaging systems were compared to 10-kg bulk packages containing individual fruit inside a 50-μm-thick LDPE film bag in terms of package atmosphere and fruit quality. Individual fruit packages consisting only of 30-μm-thick, micro-perforated OPP films without an outer liner bag were subjected to the pre-sale 0 °C storage for comparison. The master packaging systems maintained an atmosphere with O_2 concentrations of 0.8–3.9% and CO_2 concentrations of 8.4–15.0% around the fruit during storage at 0 °C and during display at 10 °C. The high-temperature retail display, after chilled storage at 0 °C, resulted in a drastic decline in quality, even with some alleviation offered by the master packaging system. The overall benefits were reduced weight loss, reduced physiological deterioration (e.g., flesh softening and surface blackening) and better retention of firmness and ascorbic acid during the chilled storage and/or the display conditions.

1. Introduction

Modified-atmosphere packaging (MAP) to maintain an atmosphere of low oxygen and high carbon dioxide has been successfully applied for non-astringent sweet persimmons using a permeable plastic film. Manually tied or heat-sealed polyethylene packages containing 1–5 fruit can create and maintain a modified atmosphere (MA) of 1–12% O_2 and 3–8% CO_2 at 0–2 °C, conferring the benefits of reduced senescence and delayed softening (Min and Oh, 1975; Lee and Yang, 1997; Ahn et al., 2001; Lee, 2004). Generally, bags made of 50–60-μm-thick polyethylene films provide beneficial MA at an optimal storage temperature of 0 °C (Bae et al., 2010; Kim et al., 2011).

At the optimally controlled temperature, the beneficial MA can be maintained, and this contributes to freshness keeping and extends the shelf life. However, high-temperature retail distribution conditions in the produce supply chain disrupt the balance between fruit respiration and package film permeation. High temperatures result in an anaerobic gas condition inside the package due to fruit respiration's greater temperature dependence than that of the packaging film's gas permeation (Exama et al., 1993; Yam and Lee, 1995; Kim et al., 2010, 2011). Respiration increases more than gas permeation with increases in temperature. Most supermarket cabinets for fresh produce are operated at temperatures greater than 5 °C, which is harmful for maintaining the desired MA.

An MAP system that is workable through the entire supply chain is desired for delivery of fresh persimmons to consumers. Primary and secondary packages that are designed with considerations for logistical management could resolve this problem. The use of master packaging in meat product distribution is an innovative concept for the effective logistic management. This concept has been developed and used in the supply chain of fresh meats as a strategy for preserving product quality and satisfying consumer needs. Master packaging can accommodate pre-sale storage and retail display conditions. Gas-impermeable masterpacks

* Corresponding author. Tel.: +82 55 249 2687; fax: +82 505 999 2171.
E-mail address: dongsun@kyungnam.ac.kr (D.S. Lee).

0925-5214/$ – see front matter
http://dx.doi.org/10.1016/j.postharvbio.2013.06.029

containing 4–12 individual retail packages are transported to the market and stored under well-controlled low-temperature conditions until opening to display the individual retail packages at higher temperatures (Gill and Jones, 1994; McMillin et al., 1999). The purpose of this system is to preserve quality during pre-sale storage and to satisfy consumer preference in the retail setting. Our hypothesis was that a packaging system that is similar to meat master packaging can be designed for persimmons.

Persimmons are commonly packaged in individual packs and are distributed in corrugated paperboard boxes as 10–20-kg units. The boxes are stored at temperatures around 0 °C during transportation and wholesale. At the retail stage, the individual packs are displayed at higher temperature (typically 10–15 °C) on supermarket shelves. As a packaging system that is workable throughout the supply chain, a liner bag in the secondary box containing the primary individual packages can be constructed to create a gas barrier that is suitable for maintaining the desired MA for the fruit. During transportation and wholesale distribution at low temperatures, the primary and secondary packages can function as gas barrier layers to reduce gas permeation and to create an MA at low temperatures. For the retail level at higher temperatures, the outer layer of the secondary package is removed to expose the individual packages to an ambient atmosphere, providing higher gas permeation to match the increased respiration. The concept of master packaging in the produce supply chain is shown in Fig. 1.

Based on the proposed concept, a master packaging system for persimmons was designed and its effectiveness was tested in maintaining an optimal MA and preserving quality for the subsequent temperature regimes of storage and display.

2. Materials and methods

2.1. Persimmons and packaging treatments

Non-astringent '*Fuyu*' persimmon fruit, freshly harvested at a farm in Changwon, Korea, on 11 November, 2009, were purchased and transported immediately to the laboratory. Fruit with an approximate mass of 210 g and without any decay or visible physiological damage were used for the experiments.

As a control treatment, bulk packages of approximately 10 kg, which are widely used for long-distance transportation and marketing, were fabricated. Forty-six persimmons were wrapped with 50-μm-thick low-density polyethylene (LDPE) film (78 cm × 77 cm). The opening of the wrapping was clipped tightly with a mechanical tie (thickness of 1.2 mm). The fruit in the bag were aligned in three layers, and a corrugated board (31 cm × 40.5 cm) was placed between the layers for stacking stability and partial stress buffering. The bag was placed in a corrugated paperboard box (44 cm × 32 cm × 24.5 cm) having 2 rectangular perforations of 2.5 cm × 9.0 cm and 6 circular perforations with a diameter of 2.5 cm.

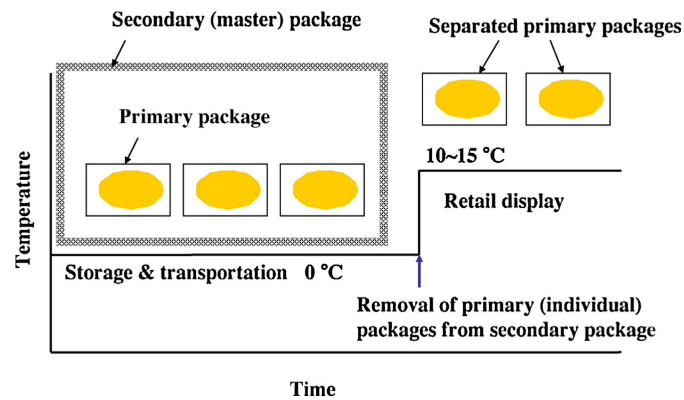

Fig. 1. The concept of a master packaging system for persimmons that is workable in a fresh-produce supply chain.

As a master packaging concept trial, 46 individual persimmon packages of 30-μm-thick oriented polyethylene (OPP) film (14 cm × 15 cm) were wrapped with the 50-μm-thick LDPE film and then placed in the corrugated box in the same way as in the bulk package. Each OPP-film bag had a micro-perforation that was made manually with a 50-μm-diameter metal needle (corresponding to micro-perforation density of 0.24/dm^2). The manual puncturing resulted in micro-perforation of wrinkled oval shapes with size of about 60 μm (average maximum diameter of 69 μm and minimum diameter of 45 μm), which was measured by a polarizing microscope (Model AX70TRF, Olympus Corp., Tokyo, Japan). As another master packaging treatment, three 12-μm-thick LDPE sachets (9 cm × 9 cm), each containing 30 g of silica gel and 5 g of zeolite, were placed in the master package to alleviate potential moisture condensation and CO_2 build-up. Fig. 2 presents

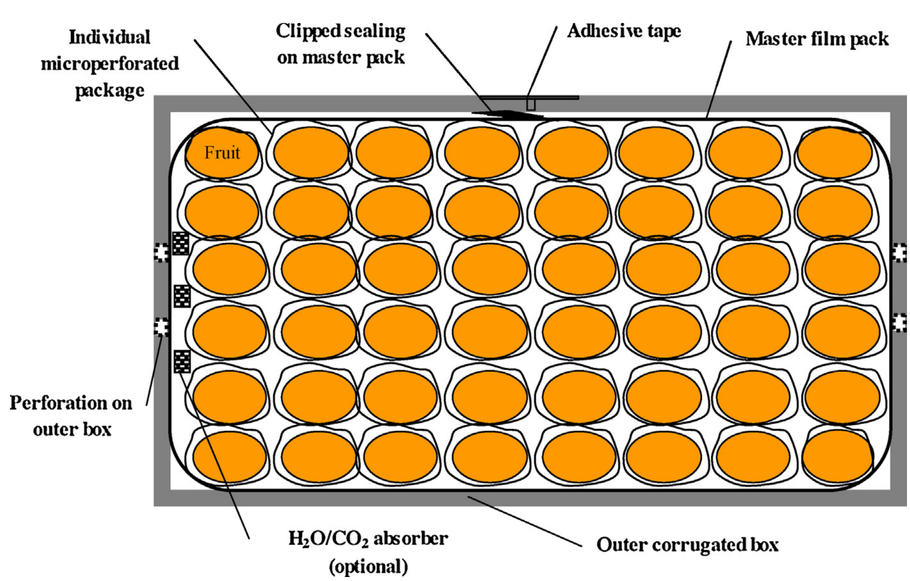

Fig. 2. A schematic diagram for the master packaging system of 'Fuyu' persimmons with optional inclusion of moisture/CO_2 absorbers.