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Preservation of Kyoho grapes stored in active, slow-releasing pasteurizing packaging at room temperature

Jingyong Zhang, Dongli Li*, Wencai Xu, Yabo Fu

Beijing Key Lab. of Printing & Packaging Materials and Technology, Beijing Institute of Graphic Communication, Beijing 102600, China

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ABSTRACT

The effects of active slow-releasing pasteurizing packaging (self-made) on the quality of Kyoho grapes were studied. Conventional polyethylene (PE) membrane with preservation tablets and naked treatments served as the control groups. Grape quality changes were evaluated by comparing sensory evaluations and experiment results. The results showed that the storage period of treatment packaged with active slow-release pasteurizing packaging can be extended to eight days. After eight days of storage, no stems were brown, and the grapes were intact; in contrast, the grade of stem browning was more than five in the PE membrane, and all the grape stems were brown in the naked treatments. In addition, the grapes' firmness was 0.59 kg/m^2, the total soluble solids (TSS) content was 14.5 mg/ml, the titratable acid content was 5 g/kg, and the vitamin C content was 3.6 mg/100 g at the end of the storage period. These results indicate that Kyoho grapes stored in this manner retain good quality, edibility, and commercial value.

1. Introduction

The Kyoho grape varietal is native to Japan and grown in hybrid form in Europe and America. It is an excellent late-maturing edible variety with large fruit berries, attractive appearance, abundant nutrition, and a sweet juice that tastes of strawberry flavor. However, it is very difficult to store because its skin is very thin and it is susceptible to decay. In addition, its storage is made more difficult because the grape berries fall off easily and are bruised because of its short fruit stem, which results in berry drop and rapid decay (Niuzhehong, 1992). When the fruits are fresh, the loss is particularly great during the process of harvesting, storing, and transportation. It takes approximately two to five days of storage and transport before the grapes reach the consumer. If one did not take any preservation measures, the quality of the grape would be compromised and decay would be a danger.

In China and abroad, SO_2 fumigation is generally used to help keep the grapes fresh (Crisosto, Garner, & Crisosto, 2002; Geyiqiang & Zhang, 1998; Pretel, Martínez-Madrid, Martínez, Carreño, & Romojaro, 2006; Zutahy, Lichter, Kaplunov, & Lurie, 2008). This method is effective for inhibiting common pathogenic grape fungi, such as gray mold, bud branch mold, and *Rhizopus nigricans* biomass. However, SO_2 fumigation can easily lead to a large amount of SO_2 residue, since the concentration is difficult to control during the operation, and these residues are detrimental to human health (Liu & Cheng, 2005). In recent years, a viable method for storing grapes has been to use modified-atmosphere packaging. Costa et al. extended the shelf life of ready-to-eat table grapes to 70 days using passive and active modified-atmosphere packaging at refrigerated temperatures. The active MAPs were made up of 5:3:92 O_2:CO_2:N_2, 10:3:87 O_2:CO_2:N_2, and 15:3:82 O_2:CO_2:N_2, respectively (Costa, Lucera, Conte, & Mastromatteo, 2011). Unfortunately, this process is more cumbersome and the investment in equipment will lead to further costs, making the cost of grape preservation 20% higher than for other fruits (Mencarelli, Bellincontro, & DiRenzo, 2005). Our active packaging material for storing grapes is less expensive and cumbersome than modified-atmosphere packaging.

Neither businesses nor consumers are willing to see such a rise in prices. Few studies have been done on grape preservation at room temperature. More research has been carried out on sulfur dioxide (SO_2)-releasing tablets and pads, while less attention has been given to placing the fungicide into flexible films to make the fungicide-releasing bag into packaging materials. In this system, SO_2 fungicide is released uniformly in self-made packaging (Xu, Li, Fu, & Wei, 2011; Xu et al., 2012), and sulfur harm caused by high local concentration of fungicides is not a problem compared with SO_2 fumigation.

In this experiment, an active slow-releasing pasteurizing packaging material (self-made) used for grape preservation was studied

Abbreviations: PE, polyethylene; TSS, total soluble solids; LDPE, low-density polyethylene; TA, titratable acid; VC, vitamin C.

* Corresponding author. Tel.: +86 13126676578.
E-mail addresses: zhangjingyong2007@126.com (J. Zhang), lidongli@bigc.edu.cn (D. Li), xuwencai@bigc.edu.cn (W. Xu), fuyabo@bigc.edu.cn (Y. Fu).

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during storage at 25 °C. In addition, conventional polyethylene (PE) membrane with preservation tablets and naked treatments served as control groups.

2. Materials and methods

2.1. Experiment materials

Fresh Kyoho grapes were harvested from a local farm in Beijing, China, and transported to the laboratory in 1 h. Grapes of uniform size and color that were free from visual defects and damage were selected.

Active slow-releasing pasteurizing packaging material with a sandwich structure (self-made) is a two-layer flexible film. The inner and outer membranes are made of low-density polyethylene (LDPE) materials modified with zeolites to increase their barrier properties. The middle layer contains polyurethane adhesive and activating materials that can slowly release SO_2 when it encounters water vapor. The thickness of outer membrane is much higher than the inner membrane in order to ensure that the fungicides are only diffused to the bag inside. Though the water vapor permeability of the laminated film is 3.528 g/m^2 day, the water vapor permeability of the inner membrane can reach 11.025 g/m^2 day due to its 15 μm thickness. That make it easy for water vapor to cross the inner membrane and reach the middle membrane, then the laminated film can slow-release fungicides. The oxygen transmission rate of the multilayer film was 912 cm^3/m^2 24 h 0.1 MPa, while its CO_2 transmission rate was 7460.2 cm^3/m^2 24 h 0.1 MPa. PE films used as control groups had water vapor permeability of 5.748 g/m^2 day, oxygen transmission rate of 1560 cm^3/m^2 24 h 0.1 MPa, and CO_2 transmission rate of 5868.2 cm^3/m^2 24 h 0.1 MPa. Preservation tablets (LONG TIAN) were kindly provided by Shanxi Longtian Trading Co. Ltd.

2.2. Treatments

Three batches of grapes were prepared: batch A (exposed to air); batch B (stored in PE film with 300 mm × 300 mm preservation tablets); and batch C (stored in slow-releasing pasteurizing 300 mm × 300 mm packaging material). Approximately 300 g fresh grapes were placed in each tray (with three replicates, i.e., 3 × 300 g), heat sealed under normal atmospheric conditions (21 kPa O_2/0.03 kPa CO_2), and stored in a ventilated place without sunshine at ambient temperature (25 °C, RH 50%). There were 21 trays of 300 g each for batch A, B, and C, respectively, out of which three trays (triplicates) were used at each sampling date. The experiments were carried out every other day, and the total test time was 14 d. The original data after harvest were obtained, and the samples were tested every other day.

2.3. Testing methods

The concentration of O_2 and CO_2 was measured using the PAC CHECK 450EC Headspace gas analyzer (Mocon, Minneapolis, MN, USA). The grade of stem browning was determined by sensory evaluation (Jayasena & Cameron, 2009), measured by a 0–10 scale based on the color of the grape stems. When the grade of stem browning is zero, there is no browning; when the grade of stem browning is 10, the grapes have browned completely. Grapes have outlived their shelf life when the grade of stem browning is more than five. The taste evaluation scale for grapes has three grades: 0–3. A score of 2–3 means the grapes are delicious, 1–2 means the grapes are edible, and 0–1 means the grapes are inedible.

A microbiology experiment was carried out based on Chinese national standard GB4789.2-2010, and the results were obtained from the average of three parallel tests. We also measured the rate of grape shatter (loss of berries from the cap stem), that is, the weight of shattered grapes/the total weight × 100%. The decay rate was assessed by the weight of decay grapes/the total weight × 100%. Weight loss rate consisted of the testing weight/the original weight × 100%.

Total soluble solids (TSS) were measured in the juice obtained from 20 berries using a digital refractometer (Atago PR-101, Atago Co. Ltd., Tokyo, Japan) at 25 °C. Results were taken as an average of 20 berries. Titratable acid (TA) was measured against the Chinese national standard GB/T 12293-90 and expressed as the percentage content of tartrate. We measured vitamin C (VC) content by using the Chinese national standard GB/T 6195-1986. Firmness was detected using an FHM-5 fruit firmness analyzer (Takemura Electric Works, Ltd., Tokyo, Japan) with a conical plunger (12 mm in diameter head, 10 mm in height). The average value was obtained from the three samples.

Finally, statistical significance was determined by the analysis of variance (ANOVA) using SAS software (version 9.1, SAS Institute Inc., North Carolina, USA). Differences among mean values were processed by Duncan's multiple range tests. Significance was defined at a level of $P \leq 0.05$.

3. Results and discussion

3.1. Gas components in different packaging materials

Gas component changes in the different packaging materials were measured, as shown in Table 1.

When the packaged item respires, it consumes oxygen (O_2) and generates carbon dioxide (CO_2) (Das, 2004). The modified atmosphere formed inside the packages is a result of the interaction between the respiration produced and the barrier properties of the packaging material (Chen, Zhang, & Wang, 2011). It can be observed that the O_2 concentration declined while the CO_2 concentration increased in packaging B and C, but the change rate of packaging C was rapid at the same storage time. That is mainly because the gas permeability of C was lower than B. The recommended gas concentrations of grapes are 2–5% for O_2 and 1–3% for CO_2 when stored at 0–5 °C (Kader, 2001). The suitable atmosphere surrounding fruit may change at different temperatures. From Table 1,

Table 1
Oxygen and Carbon dioxide concentrations of Kyoho grapes in different packaging materials during storage at room temperature.

Treatments		Storage time (days)							
		Initial	2	4	6	8	10	12	14
A	O_2 (%)	21.0 ± 0.0	21.0 ± 0.0	21.0 ± 0.0	21.0 ± 0.0	21.0 ± 0.0	21.0 ± 0.0	21.0 ± 0.0	21.0 ± 0.0
	CO_2 (%)	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0	0 ± 0.0
B	O_2 (%)	21.0 ± 0.0	19.6 ± 0.1	19.0 ± 0.1	19.2 ± 0.2	18.2 ± 0.1	18.6 ± 0.1	18.4 ± 0.2	18.1 ± 0.1
	CO_2 (%)	0 ± 0.0	0.7 ± 0.1	1.6 ± 0.1	1.6 ± 0.2	2.0 ± 0.1	2.4 ± 0.1	2.5 ± 0.3	2.6 ± 0.1
C	O_2 (%)	21.0 ± 0.0	12.3 ± 0.3	6.6 ± 0.2	5.5 ± 0.2	4.8 ± 0.1	4.8 ± 0.2	4.1 ± 0.1	1.3 ± 0.1
	CO_2 (%)	0 ± 0.0	3.9 ± 0.1	5.5 ± 0.1	6.3 ± 0.1	7.3 ± 0.3	8.9 ± 0.3	10.2 ± 0.1	10.8 ± 0.4

A – exposed to air; B – PE + tablet; C – slow-releasing bag; the results were obtained from the average of three parallel tests. Significance was at a level of $P \leq 0.05$.