

Development of an Automatic Monitoring and Controlling System for a Controlled Atmosphere Storage of Mangos

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Abstract: The main purpose of this study develop an automatic monitoring and controlling system for a controlled atmosphere (CA) storage of mangos. The gas conditions during storage with controlled atmosphere technology were investigated and some improvement schemes were proposed, in order to maintain the quality of the whole packaged mangos. Combined with the existing temperature, humidity and time recording instruments of a storage environment, an automatic detecting and adjusting system of a CA storage of mangos was developed. The gas conditions in a CA storage can be monitored and also were fully controlled. The whole storage process for mangos can be regulated in time by the adjustment of individual gas proportion. In this study, fully ripe mangos were stored at 6% O₂ and 4% CO₂ at 13°C, and compared with mangos stored at 21% O₂ and 0.08% CO₂ at 20°C in the air as a control. Mangos were removed from CA storage one week after storage and different quality parameters were measured by several detectors. The results of this study are the mangos stored in CA storage showed better retention of freshness, color, firmness and flavor as compared to the mangos stored in the air. In addition, the mangos were stored at 6% O₂ and 4% CO₂ at 13°C can obtain best storage quality of mangos. Mangos held in the air were highly unacceptable due to overripe and off-flavor. Therefore, this study of an automatic monitoring and controlling system for a CA storage not only the quality of fruits can be preserved for domestic market, but also these fruits have their international competitiveness when they are exported to other countries.

Key words: Mango, controlled atmosphere (CA), storage

INTRODUCTION

Some of the positive effects of optimum low O₂ and high CO₂ storage atmospheres on fruit crops are reduced ethylene production and respiratory activity, better flavor retention, slower softening rates and slower green color loss (Thompson, 1998).

Many types of produce have been observed to respond to controlled atmosphere in the laboratory, but only a few fruits, such as apple and pear, are commercially stored under CA conditions to increase their storage life (Scott, 1984). Hatton and Reeder (1967) found that Keitt mango was best stored for 20 days at 13 °C under CA containing 5% O₂ and 5% CO₂. Athapol and Nirat (1995) reported that Rad mangoes can be stored for 7 days at 13 °C in CA storage containing 6% O₂ and 4% CO₂.

In general, postharvest life of tropical fruit, for example, mango, banana and papaya, is extended by 50-100% when kept in CA relative to air at optimum temperature and relative humidity (Kader, 1993).

The main purpose of this study is to develop an automatic monitoring and controlling system for a CA storage of mangos. The gas conditions during storage with controlled atmosphere technology will be investigated and some improvement schemes will be proposed, in order to maintain the quality of the whole packaged mangos. Combined with the existing temperature, humidity and time recording instruments of a storage environment, an automatic detecting and adjusting system of a CA storage of mangos will be developed.

MATERIALS and METHOD

The CA storage chamber (size 180X90X270cm) is shown in Figure 1 was used. Pressurized CO₂ and N₂ gas cylinders with separate flow meter were used to prepare the desired atmospheres. The gases and air were entered the CA storage chamber. Gas flow rates from the cylinders and air were adjusted by using a solenoid valve system to obtain the required gas concentrations. The excessive gas could be exhausted outside the CA storage chamber to prevent CO₂ accumulation and overpressure. The CO₂ and O₂ concentrations were checked by gas detectors and could also be recorded by a computer.



Figure 1. Controlled atmosphere storage chamber

The gas conditions in a CA storage can be monitored and also will be fully controlled. The whole storage process for mangos can be regulated in time by the adjustment of individual gas proportion. In this study, fully ripe mangos were stored at 6% O₂ and 4% CO₂ at 13°C, and compared with mangos stored at 22% O₂ and 0.08% CO₂ at 20°C as a control. Mangos were removed from CA storage one week after storage and different quality parameters were measured by several detectors. The O₂ and CO₂ concentrations inside the CA storage chamber were measured by means of a CO₂ monitor/controller (Model M304; Digital Control Systems Inc., Portland, OR, USA) and an O₂ transmitter (Model GPR-2500, Advanced Instruments Inc., Norwood, MA, USA) as shown in Figure 2 and Figure 3.

Figure 4 shows a digital signal transmitter for ethylene (Model AST-EC4; Critical Environment Technologies Inc., Delta, BC, CANADA) that can measure the ethylene (C₂H₄) concentration inside the CA storage chamber.

Ethylene that released from the fruits was observed and decomposed with activated Potassium manganite (KMnO₄) in the CA storage chamber.



Figure 2. Carbon dioxide monitor/controller (M304)



Figure 3. Oxygen transmitter (GPR-2500)



Figure 4. digital signal transmitter for Ethylene (AST-EC4)

Figure 5 shows the mango samples that were purchased directly from the orchard in Pingtung county, Taiwan. The mangoes were packed and transported to the laboratory within 24h after harvesting. Only sound and uniform mangoes were

used in the experiment. All of the mangoes were stored at 13 °C with 80-90% relative humidity for one week, after which the mangoes were removed from the storage chamber and then analyzed by different quality parameters.



Figure 5. Mangoes (*Mangifera indica* L.)

Fruit firmness was measured in kilogram (kg) using a fruit hardness tester (Model FHM-5; Takemura Denki Manufacture Co., Tokyo, Japan) after the CA experiment as shown in Figure 6. The level of damage observed in each mango was evaluated from fruit firmness tester. Mangoes were randomly selected for evaluation with a fruit hardness tester. Flesh firmness was measured on the equator of the fruit. This portable fruit hardness tester was equipped with a conical measuring probe (12.3mm diameter).



Figure 6. Fruit hardness tester (FHM-5)

RESULTS and DISCUSSION

The initial gas composition of CA was 22% O₂ + 0.08% CO₂ + 77.92% N₂. The gas concentration could be held at 6% O₂ + 4% CO₂ + 90% N₂ several days in the CA experiment as shown in Figure 7. It is evident that the gas conditions in a CA storage chamber could be monitored and controlled effectively.

Changing the CO₂ and O₂ in the storage atmosphere showed that in a statistically significant

effect on weight loss of mangoes. The fruits stored in an open air exhibited a higher weight loss as compared to the fruits stored in the CA chamber. The Figure 8 shows the result of control samples in open air after one week. Mangoes stored in air showed a higher weight loss than that stored in atmospheric gas of 6% O₂ and 4% CO₂ at 13 °C as shown in Table 1. However, The lower weight loss in fruits held in air in the closed chamber investigations could be due to combination of a build up of humidity and lower respiration. It is well documented that CA treatments build up humidity and reduced respiration of fruits due to this reason weight loss of fruits decreased while in open climate higher respirations increased the weight loss of fruit (Kader, 1993).

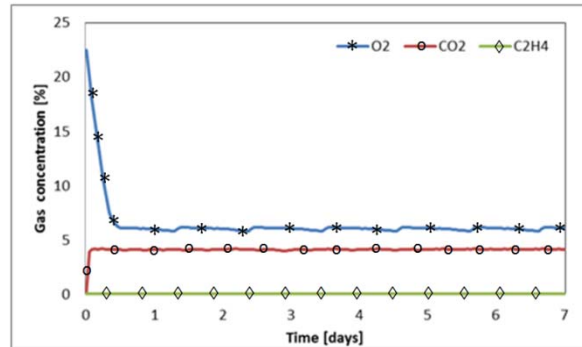


Figure 7. Changes in oxygen and carbon dioxide and ethylene concentrations during controlled atmosphere storage



Figure 8. Control set (open air)

Fruits held at 6% O₂ and 4% CO₂ at 13°C showed a higher fruit firmness than the control set as shown in Table 1. Regarding the firmness, mangoes stored in CA represented the excellent results by retaining the maximum firmness as compared to air. The current

Table 1. Quality parameters of mangoes stored under CA conditions at 13 °C one week.

Treatment	Weight loss (%)	Firmness (kg)
CA: 6% O ₂ + 4% CO ₂	1.86	4.1
Control set (in an open air)	2.98	3.3
Initial reading	-	4.2

investigations confirm the view that CA conditions delay fruit ripening and softening (Thompson, 1998). Furthermore, the rate of Rad mango softening during storage at 13°C for one week was significantly reduced in fruits exposed to 6% O₂ with 4% CO₂ relative to those kept in air (Athapol and Nirat, 1995).

The results of this study show that the mangos stored in CA storage had a better retention of freshness, color and firmness as compared to the mangos stored in the air. Mangos held in the air were highly unacceptable due to overripe and off-flavor. In addition, the mangos were stored at 6% O₂ and 4% CO₂ at 13°C can obtain a best storage quality of mangos.

CONCLUSIONS

Combined with the existing temperature, humidity and time recording instruments of a storage

environment, an automatic detecting and adjusting system of a CA storage of mangos is developed.

Controlled atmosphere storage is feasible for extending the shelf life of ripe mangoes. The treatment of 6% O₂ and 4% CO₂ emerged as optimal atmospheric conditions for the storage of fully mature mangoes. After the development of this automatic monitoring and controlling system for a CA storage, not only the quality of fruits can be preserved for domestic market, but also these fruits have their international competitiveness when they are exported to other countries.

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