Simulation 2 - Long-term storage of `Carabao' mango fruits to simulate shipment to distant market

Using cold-storage technique in combination with different shelf life enhancing treatment

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Title	Simulation 2- Long-term storage of `Carabao' mango fruits to simulate shipment to distant market Using cold-storage technique in combination with different shelf life enhancing treatment
Author	Sherman Chavez T: +63 (0) 917 700 6513 sherman.chavez@freshstudio.biz
Date	September 10, 2007
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Contact address	Fresh Studio Innovations Asia 1 Ladislawa Avenue, Buhangin Davao City 8000 Philippines T: +63 (0) 82 227 6776 F: +63 (0) 82 227 6775 W: www.freshstudio.biz

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Reviewers

Name	Function
1. Antoine Miltenburg	Mango Project Manager

Content

1. Introduction

The Philippine 'Carabao' mango is no doubt one of the best-tasting mangoes in the world. It always land on the top 3 best tasting mangoes whenever there are international food expositions. Our very own mango has a very bright future in the international trading arena.

Currently, the fruits are being marketed to destinations which are quite nearer geographically such as Hongkong, China and Japan. These markets currently absorb more than 90% of the total volume of fresh mango being exported from the Philippines. But as other markets are opening up, and other countries are slowly entering the markets dominated by the Philippines, there is a constant need to explore other possibilities and potential. Singapore, UK, Switzerland, Korea, Middle East and other parts in Europe are just some of the many destinations in which our mango has great potential. But knowing the distance of these markets poses other problems in our industry, the cost of transporting this commodity and the relatively short shelf life of the fruit.

For destinations such as in Europe and the Middle East, the easiest way to bring in mangoes is thru air-shipment. But the freight cost of doing so is so much (60% of the total cost) that our industry cannot simply ship it thru air otherwise, they are bound to fail. Other alternative needs to be explored and tested to cut on the cost without sacrificing the quality of the fruits. Shipment thru vessel is just another way to solve the problem on transport cost but the problem will remain on the quality of fruits once exposed to this condition. Several trials need to be done on the compatibility of the procedure versus eventual quality of the fruits after withdrawal. Other shelf life enhancing treatments need to be explored to fully maximized and complement the potential of cold storage as technique that will extend the postharvest life of fresh mango fruits.

2. Objectives

1. To test the potential of using sea-shipment as an alternative way to transport mangoes to distant markets using simulation transport trials.
2. To explore other means of prolonging the shelf life of the fruits in compatibility with long-term cold storage.
3. To determine subsequent quality of the fruits once exposed to such condition.

3. Methodology

3.1 Sourcing of fruits

Fruits were obtained from a consolidator based in Davao City. The fruits were sourced out from New Valencia, Tugbok district, Davao City. A total of 1.5 tons of green, mature, freshly harvested 'Carabao' mango fruits were obtained as experimental material. Class B fruits (Hongkong grade) were selected as samples with no serious defects such as cuts, bruise, deep wounds or insect damage. Only about 10% of the surface was set as the maximum tolerance allowable for defects such as scab and latex stain. Fruits were packed in used banana boxes and were transported to the packinghouse early evening.

3.2 Box used for simulated transport

Final packaging for simulated transport consisted of box made from corrugated carton with the dimension of 45 x 30 x 13 cm. Bottom was provided with polyethylene foam .

3.3 Preparation for treatment

3.3.1. Storage in reefer van (study 1 and 2)

Selected fruits were divided into treatments under study 1 and 2 as specified in Tables 1 and 2. Heat treatment of mangoes was done by dipping mango fruits in heated water with azoxystrobin at certain temperature and duration. Afterwards, hydrocooling was done by dipping mangoes in tap water, also with azoxystrobin, for 5 mins to immediately cool down the fruits. Fruits then were allowed to dry before putting in the necessary treatment like wax coating, the X-tend plastic and ethylene scrubber.

Where applicable, wax coating was applied on fruits using brush; for each X-tend bag a total of 15 fruits were placed; and for the ethylene scrubber 1 piece was put in per box. Once packed in box, fruits were pre-cooled first to 0^{o}C for 2 hours using blast freezer. After pre-cooling, fruits were then transferred to a reefer van pre-set to 12.5^{o}C. Fruits were stored for twenty seven (27) days in this condition. Vent opening in van was adjusted to 30 cfm to regulate entry and exit of gases. Part of the empty space in the van was covered with double-wall corrugated board to avoid short-cycling of the cold air inside the van. Close monitoring of the temperature, relative humidity and van condition was done in the whole duration of the storage. At the end of the twenty seven day - storage period, fruits were withdrawn and evaluated for quality, internal and external. The remaining fruits after the evaluation were allowed to ripen at 22-26^{o}C for 5 days. Evaluation of the quality of the remaining fruits was also conducted when fruits turned full yellow in color.

Storage in Reefer Van

Treatments for Study 1.

Table 1. Different shelf life enhancing treatments

Treatments	No of box	CODE
1 – wax coating – code Red	30	**WR**
2 – wax coating – code Black	30	**WB**
3 – wax coating – code Gold	30	**WG**
4 – X-tend plastic	30	**XP**

Note: hot water treatment procedure used for all treatment was 53^{o}C, 7 min dip with azoxystrobin + 5 min hydrocooling with azoxystrobin also

Storage in Reefer Van

Treatments for Study 2

Table 2. Different hot water treatment procedures

Treatments	No of boxes	CODE
1 – 53^{o}C, 7 min dip with azoxystrobin + 5 min hydrocooling with azoxystrobin	70	**RVH1**
2 – 53^{o}C, 10 min dip + 5 min hydrocooling with azoxystrobin	70	**RVH2**
3 – 57^{o}C, 3 min dip with azoxystrobin + 5 min hydrocooling with azoxystrobin	70	**RVH3**

Note: each box was placed with 1 sachet of ethylene scrubber

4. Data gathered

1. No. of days to full yellow color - days after withdrawal of the fruit from cold storage to full yellow color

2. Color index of fruit after withdrawal from cold storage

3. Anthracnose incidence - percentage of fruits with disease after withdrawal from the storage and when fruits were ripe after exposure to ambient condition

4. Brix level at full yellow color – level of sweetness to be measured using a refractometer

5. Results and Discussion

Number of days to full yellow color after withdrawal from cold storage

Study 1 **-** Table 3 presents the results for all the treatments tested. Fruits enclosed in the Xtend plastic bag took 3 days to totally turn yellow after exposure to ambient condition. Coatings failed to produce the desired results. Regardless of the coating used, all fruits failed to turn full yellow even when exposure was extended for 6 days. Fruit pulp became shriveled and soft also.

Study 2 **-** for the fruit applied with different hot water treatment procedures, regardless of procedures used, fruits turned full yellow after 2 days from exposure from ambient condition (Table 4).

Color index of fruit after withdrawal from cold storage

Study 1 – the treatments used were really effective in slowing down the color development in fruits. As seen in Table 5, color index were in the range of 3.0-3.5 which means fruits were around 40-50% yellow upon withdrawal. Drawback in using the coating is that color development did not advance any further from the time the fruits were withdrawn. The color remained the same yet the pulp is soft and ripe already. Used of the coating seemed to greatly inhibited or regulated the gas exchange between the peel and its surrounding. As for the plastic bag, color development continues until day 3 upon exposure to ambient condition.

Study 2 – color development of fruits were almost the same regardless of heat treatment procedure used in study 2 (table 6). The values ranged from 4.5 – 5.0, which means fruits were around 80-90% yellow already.

Anthracnose incidence

Study 1 – anthracnose incidence after withdrawal from cold storage was slight for all treatments, ranging from 0-12% only (Table7). It was interesting to note that fruits enclosed using the Xtend plastic bag had a zero (0) percent disease incidence. After the fruits were exposed to ambient condition for some time, those that were applied with coating had a moderate to severe anthracnose incidence (30-48%) but surprisingly, those fruits enclosed in the plastic bag had only 2% incidence when full yellow. The plastic bag seemed to inhibit the development or growth of the fungus causing the disease.

Study 2 – disease incidence for fruits that used different hot water treatment procedures were slight, ranging from 8-10% (Table 8). When fruits were allowed to ripen at ambient condition for 2 days, disease incidence increased, ranging from 10-19%. It was heat treatment 1, using the 53^{o}C temperature and 7 min dip with azoxystrobin which afforded a better control of the disease.

Brix level at full yellow color

Study 1 - fruits applied with the coatings failed to turn yellow even when ripening period was extended for a few more days. Thus, brix level was not determined for fruits under these treatments. Fruits under the Xtend plastic bags had 16.7 ^{o}Brix, still sweet, typical of a "Carabao" mango fruit even if stored for 27 days (Table 9).

Study 2 – brix level for fruits that undergone different hot water treatment procedures were a bit lower, or less sweet. Values ranged from 12.7 – 14.5 ^{o}Brix only. The condition during the 27 day – storage period affected the level of sweetness of the fruits, in particular the temperature at which the fruits were exposed during its ripening period. More on the function of the storage condition than the effect of the heat treatment procedures on fruits.

Table 3. Number of days to full yellow color after withdrawal from cold storage and stored at ambient condition, as influenced by different shelf life enhancing treatment

Treatment	Days
1 – coating 1 (code Gold)	na
2 – coating 2 (code Red)	na
3 – coating 3 (code Black)	na
4 – Xtend plastic bag[1]	3

NA - not applicable; mangoes didn't turn yellow at all even when exposure was extended for 6 days; but pulp was soft already

[1] mangoes inside the plastic were taken out and allowed to ripen totally exposed

Table 4. Number of days to full yellow color after withdrawal from cold storage and stored at ambient condition, as influenced by different hot water treatment procedures[1]

Treatment	Days
1 – 53^{o}C, 7 min dip with azoxystrobin + hydrocooling with azoxystrobin for 5 mins	2
2 – 53^{o}C, 10 min dip + hydrocooling with azoxystrobin for 5 mins	2
3 – 57^{o}C, 3 min dip with azoxystrobin +hydrocooling with azoxystrobin for 5 mins	2

[1] 1 sachet of ethylene scrubber was placed in each box of mango

Table 5. Peel color index of fruits after withdrawal from cold storage, as influenced by different shelf life enhancing treatment

Treatment	PCI[1]
1 – coating 1 (code Gold)	3.5
2 – coating 2 (code Red)	3.0
3 – coating 3 (code Black)	3.3
4 – Xtend plastic bag[1]	3.3

[1] peel color index = arbitrary rating for color development; 1-green; 2-color break;3-more green than yellow; 4-more yellow than green; 5-tinge of green; 6-full yellow

Table 6. Peel color index of fruits after withdrawal from cold storage, as influenced by different hot water treatment procedures[1]

Treatment	PCI[1]
1 – 53^{o}C, 7 min dip with azoxystrobin + hydrocooling with azoxystrobin for 5 mins	5.0
2 – 53^{o}C, 10 min dip + hydrocooling with azoxystrobin for 5 mins	4.7
3 – 57^{o}C, 3 min dip with azoxystrobin +hydrocooling with azoxystrobin for 5 mins	4.5

[1] peel color index = arbitrary rating for color development; 1-green; 2-color break;3-more green than yellow; 4-more yellow than green; 5-tinge of green; 6-full yellow

Table 7. Anthracnose incidence in fruits after withdrawal from cold storage and when full yellow after storage at ambient condition, as influenced by different shelf life enhancing treatment

Treatment	Anthracnose incidence (%)	
	After withdrawal	Full yellow at ambient
1 – coating 1 (code Gold)	12.0	30.0
2 – coating 2 (code Red)	7.0	48.0
3 – coating 3 (code Black)	8.0	37.0
4 – Xtend plastic bag[1]	0	2.0

[1] mangoes inside the plastic were taken out and allowed to ripen totally exposed

Table 8. Anthracnose incidence in fruits after withdrawal from cold storage and when full yellow after storage at ambient condition, as influenced by different hot water treatment procedures

Treatment	Anthracnose incidence (%)	
	After withdrawal	Full yellow at ambient
1 – 53^{o}C, 7 min dip with azoxystrobin + hydrocooling with azoxystrobin for 5 mins	8.0	10.0
2 – 53^{o}C, 10 min dip + hydrocooling with azoxystrobin for 5 mins	10.0	15.0
3 – 57^{o}C, 3 min dip with azoxystrobin +hydrocooling with azoxystrobin for 5 mins	8.0	19.0

Table 9. Brix level of fruits when full yellow, as influenced by different shelf life enhancing treatment

Treatment	^{o}Brix
1 – coating 1 (code Gold)	na
2 – coating 2 (code Red)	na
3 – coating 3 (code Black)	na
4 – Xtend plastic bag	16.7

NA – not applicable = fruits didn't turn full yellow after some time and thus not included in the measurement

Table 10. Brix level of fruits when full yellow , as influenced by different hot water treatment procedures[1]

Treatment	^{o}Brix
1 – 53^{o}C, 7 min dip with azoxystrobin + hydrocooling with azoxystrobin for 5 mins	12.7
2 – 53^{o}C, 10 min dip + hydrocooling with azoxystrobin for 5 mins	14.5
3 – 57^{o}C, 3 min dip with azoxystrobin +hydrocooling with azoxystrobin for 5 mins	13.8

6. Summary

Long term cold –storage of mango entails a different approach from the standpoint of a grower and postharvest technologist. One technique should always complement the other to have an effective control of the quality of the fruits, especially on disease control - preharvest or postharvest maybe the case.

Use of coating was not effective in prolonging the shelf of the fruit even when in combination with cold storage technique. Peel color development was affected and disease level was moderate to high. Use of different heat treatment procedures came up with a certain level of shelf life extension by minimizing the disease but ripening was in a much advance stage. On the other hand, the use of plastic bags extended shelf life by effectively controlling disease development and peel color development (ripening), but of course in combination with hot water treatment also.

7. Acknowledgement

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- P-Viation for the different fruit coatings
- StePac for the Xtend plastic bags

8. Appendix Figures

Figure 1. Quality of mango fruits enclosed in Xtend plastic bags before and after simulated trial for 27 days under 12.5^{o}C

Figure 2 Quality of mango fruits applied with hot water treatment before and after simulated trial for 27 days under 12.5^{o}C

Figure 3. Quality of mango fruits applied with different coatings before and after simulated trial for 27 days under 12.5^{o}C

Figure 4. Quality of untreated mango fruits (control) after withdrawal from cold storage