AGROTECHNOLOGY &
FOOD SCIENCES GROUP
WAGENINGEN UR

Fact-finding Mission: Melon Quality in the US Supply Chain

Screening postharvest handling of Caribbean Gold RZ melons

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Report 1019

Content

1 Introduction

Maintaining a year round, high quality level of melons especially Cantaloupe and Galia varieties is a major challenge. Retailers, wholesalers and other participants in the supply chain observe repeatedly lacking quality and try to find solutions for this problem. Due to the poor quality (taste, visual appearance and rot infections) consumers become disappointed and do not repeat their purchase for these types of melons. For Rijk Zwaan, who plays a important role in the breeding of these cultivars, this situation is threatening on the long term. Growers sometimes claim that intrinsic cultivar properties might cause the varying or poor postharvest quality. Rijk Zwaan's observation is that some growers are perfectly capable in producing high quality melons on a regular base using Rijk Zwaan's varieties. Although harvest and postharvest protocols are available and shared with growers/packers it might be that in the real world situation these protocols are not implemented properly. The picking moment, the variation in ripening stage at picking and the temperature management in the whole chain are most likely the essential issues here.

2 Methods

To get a good insight in the postharvest operation of melons, with special attention to Caribbean Gold RZ (CG RZ), a postharvest specialist of AFSG performed a screening of postharvest procedures and processes in the supply chain. Two companies were visited: The Fresh Quest arrival and distribution locations in the U.S. (Pompano Beach, Florida and Port Canaveral, Florida) and the Fresh Quest melon farm (Fruta Mundial) in Zacapa, Guatemala, see Picture 1.

Picture 1: Product flow (source: google maps)

In Guatemala three field tests were done to have a first idea of the postharvest treatments on fruit quality. In the first test handling damage during harvest was observed. In the second test the effects of different postharvest treatments were evaluated. In the third test two special treatments were evaluated. All tests were on a small scale level and specific for CG RZ melon produced by Fruta Mundial.

3 Results

The chain was screened upstream. This means that first at the destination (Florida, U.S.) the quality of the received product was screened and secondly the processes at the source became point of study (Zacapa, Guatemala).

3.1 Florida U.S.

3.1.1 Process

The pallets with fruit arrive either by reefer container or by refrigerated vessel in Florida. Before entry into the U.S. the pallet/cargo is inspected by Homeland Security. The reefer containers are unloaded with the use of forklift trucks and the product is directly put in a cold store. A reefer vessel is unloaded using a crane and the pallets are transported from the cay to the refrigerated warehouse on trolley's. In both situations the pallets wait in the cold store to be picked up for further distribution through the U.S.

> The intended closed cold chain is broken here. The vessel is unloaded and the fruit need to wait on the cay for transportation into the cold store. The observation is that this takes only several minutes, so no big impact on quality is expected i.e. product temperatures will hardly rise. The compact pallet stack needs hours before significant temperature abuse can occur.

3.1.2 Quality

The overall quality upon arrival in the U.S. was fair to fairly good, scale [poor, fair, fairly good, good]. The fruit was firm and had a tight seed cavity. No mold was found. The fruit was fairly well to well netted [scale fairly well, well, very well] and had a green to light green background color [green, light green, straw]. The major quality defects we observed were sunken area's and bruising / scuffing of the fruit. 41% of the fruits showed scars and scuffs. 12% of the fruit showed sunken area's. In time these sunken area's will discolor and influence sale ability in a negative way.

Sunken discolored area's

No netting on sunken area's

3.2 Guatemala

3.2.1 Process

3.2.1.1 Harvest

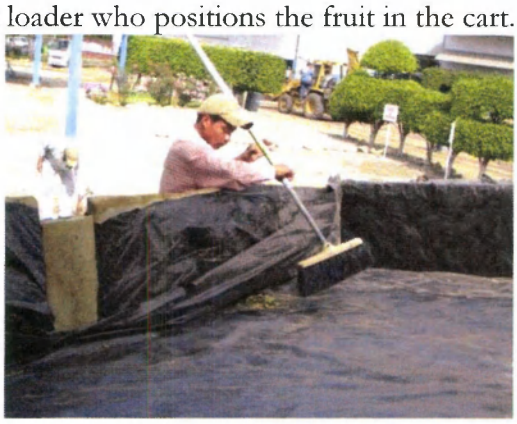
Fruit is harvested during day time. Two pickers harvest the fruit, one evaluates harvest stage and cuts the fruit from the plant (Caribbean Gold is a variety that does not slip). Then the fruit is handed to the second picker who lays the fruit in the pick up path on the field. The temperature in the field was measured and appeared to be 30°C.

The fruit at harvest was not fully mature. For the pickers this is difficult to see. One has to be trained well and must have expertise and knowledge to be able to distinct when the fruit is at the correct harvesting stage. The impression is that this needs improvement.

3.2.1.2 Loading

After laying in the field for 1 – 1.5 hours two loaders load the fruit on a cart, one picks up the fruit out of the path and hands it over the second loader who positions the fruit in the cart.

Fruit in cart



Foam and black plastic

It takes max 1 – 1.5 hour before the fruit is loaded on the carts. The fruit lays in the full sun causing an increase of pulp temperature and dehydration. The inside of the cart has foam covered with black plastic. The black color heats up in direct sunlight. Measured temperature of the plastic in the field is 45°C. The fruit in the cart is not protected from direct sunlight. Measured temperatures on surface of the melons were in the range of 30 to 35°C. In February and March temperatures are higher in the Zacapa area. In appendix 1 internal temperatures are shown. It's clearly visible that temperature rises.

3.2.1.3 Transport

If more carts are loaded (8 – 10) a train is formed to transport the fruit to the pack house. After 1 – 1,5 hours the melons are transported to the pack house.

3.2.1.4 Unloading

The train of carts is driven on a bank and the side is opened of the cart. The fruit rolls out of the cart into the pack house.

The fruits bounce on each other when unloaded. Introducing bruises i.e. much mechanical damage.

3.2.1.5 Brushing

The fruit directly rolls onto the brushes where the fruit is sprayed with water and brushed.

3.2.1.6 Washing

After the brushes the fruit rolls into a disinfection bath with washing water containing 200 – 250 ppm chlorine.

Unloading of the fruit

Brushing and washing

3.2.1.7 Grading

The fruit is lifted out of the water by an elevator onto a selection belt where graders grade the fruit in 3 grades. Grade 1, grade 2 and fruit for the domestic market.

3.2.1.8 Sorting

Directly after grading the fruit rolls on the sorting machine which sorts the fruit in size 15, size 12, size 9 and size 9 jumbo.

3.2.1.9 Bin packing

For internal handling the fruit is packed in large bins (ca. 1m^3). The fruit rolls off the grading and sorting belt into the bin.

The force on the fruit might be too high in the lower parts of the bins. Some pressure points have been observed after storage. It is not known if these were introduced by the storage in the bins or if it was caused earlier in the chain. In the whole process of brushing, washing, grading, sorting and bin packing the fruit makes many drops which causes mechanical damage (bruising and abrasions).

Grading and Sorting

Bin Packing

3.2.1.10 Pre-cooling

The bins are stacked three high and placed in a forced air pre-cooler. Using intervals of one hour the temperature of the melons is monitored. If the temperature reaches the level of 4 – 5°C the fans are switched off and the fruit bins are moved to the buffer storage. I takes four to five hours to pre-cool the fruit to 4 – 5°C.

The temperature might be too low for CG RZ, The effect of low temperature on the quality of CG RZ is not known. (by the farmer) The time (4 – 5 h) may be too long causing dehydration, The effect of dehydration on CG RZ quality is not known. (by the farmer)

3.2.1.11 Buffer storage 1

After pre-cooling the bins are stored in the buffer where the fruit waits to be packed in cartons. The setpoint of this store is 4°C.

3.2.1.12 Packing

The bins is tipped over on a belt where packers take the fruit and pack it into a carton. The fruit is packed in a bag. The bag is closed and the carton glued and closed. The packing room setpoint is 9°C.

Again the fruit makes here a drop of ca. 20 cm; the fruit bounces onto the belt. The belt is completely filled with melons rubbing against each other and most likely causing abrasions.

3.2.1.13 Stacking

Directly after packing the cartons are stacked on pallets. The pallets are stacked in the room where the cartons are packed (9°C).

The size of the cartons does not fit with the size of the pallet. Chimneys are created halfway through the pallet via the stacking pattern. Because of the stacking pattern the weight of the cartons is not distributed over the strongest part of the cartons

Packing

Stacking

3.2.1.14 Buffer storage 2

The pallets are stored in a cold room to wait for loading on a truck / reefer container. The cold room set point is 9°C

3.2.1.15 Loading

The pallets are loaded via a loading dock into trucks or reefer container. The dock is a separate room next to the buffer storage. The dock is insulated.

The reefer containers are pre-cooled to 36°F (2°C).

The loading dock is not temperature controlled but insulated, the cushioning around the doors of the dock do not close off the openings between the container door and the dock. Warm (humid) air can enter the container and will condensate since the container is pre-cooled. The humidity/condensation can effect the performance of the cartons.

The end of the T-bar and pallets is not covered when the container is fully loaded (see picture next page). Cold supply air can 'escape' around the back instead of going through the cartons.

No tight fit between container and dock

T-bar floor left open

3.2.1.16 Transport

The fruit is transported to the port.

3.2.2 Quality Field Test

During the visit three field tests were performed. In the first field test the accumulation of the damage i.e. bruising in the process was counted. In the second test the effect of pre-cooling and packaging was tested. In the third test fruit was packed before tipping on the packaging belt and the other treatment was packing of the fruit after tipping.

3.2.2.1 Field test 1

In the process (harvest-loading in container) it was observed that the fruit is damaged. In a simple test the amount of damage from harvest to washing was counted. Marked fruit entered the process at three different stages: before transport (T), before brushing (B) and before washing (W). The sample size was 20 melons for each point. After the washing step the fruit was extracted out of the process and additional damage was counted again (Figure 1). The results are presented in Table 1.

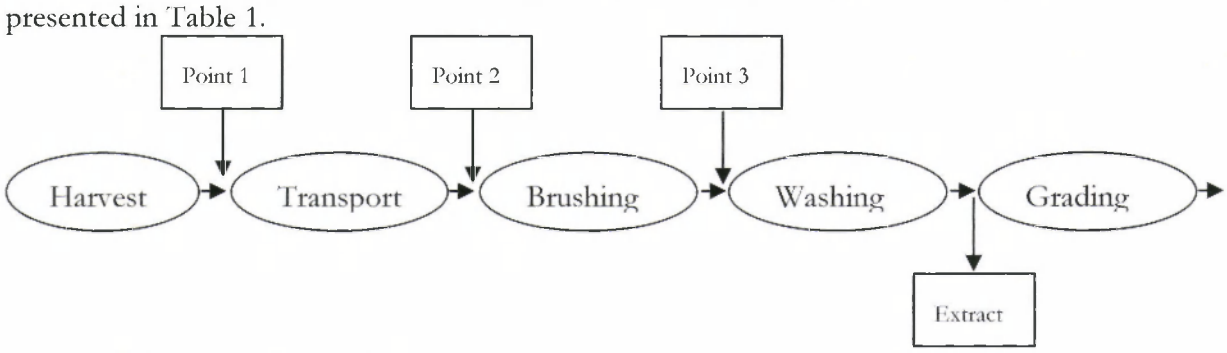


Figure 1: Entry point of melons in process

Table 1: Results of field test 1

Point	Additional surface damage (20 melon average)
1	5.25 (a)
2	3.80 (a)
3	1.00 (b)

Marked fruit in transport

Marked fruit before brushing

3.2.2.2 Field test 2

The fruit that was used in field test 1 was used in test 2 as well. The melons were treated with 4 variables:

- Field treatment (Field test 1)
- Position on cart (not in table)
- Pre-cooling Yes/No
- Bag in carton Yes/No

After the melons were packed in the carton they were stored in the cold storage at 9°C. The treatments are presented in Table 2.

Table 2: Treatment field test 2

No	Field treatment	Pre-cooling	Bag in Carton
1 to 5 and 11 to 15	T + B + W[1]	Yes	Yes
6 to 10 and 16 to 20	T + B + W	Yes	No
21 to 30	B + W	No	Yes
31 to 40	B + W	No	No
41 to 50	W	Yes	Yes
51 to 60	W	No	Yes

The fruit was stored for 7 days at 9°C, afterwards the quality of the melons was checked on several aspects: Color. Subsidence (sunken area's) & Scars, Mold, Firmness and General Appearance. A further storage period of 5 days at 20°C was added to simulate a retail phase. The same quality aspects were assessed with additional brix and psi (firmness, Pounds per square inch) measurements.

Quality after storage period

From the data acquired directly after the 9°C storage we can conclude:

- Pre-cooling had no direct effect on all quality aspects
- 30% of the T+B+W melons suffered from mold infections
- The T+B+W and B+W treatments showed more subsidence and scars. The same result as in the first 'damage' test
- Bags in the carton for packing had a significant effect on firmness and general appearance. The melons packed in a bag had a good firmness, where without a bag the firmness was regular to bad. Remarkable is that without a bag the fruit showed more subsidence and scars. The general appearance without a bag was bad to regular. The results are visualized in Figure 2.

[1] *T = Transport, B = Brushing, W = Washing*

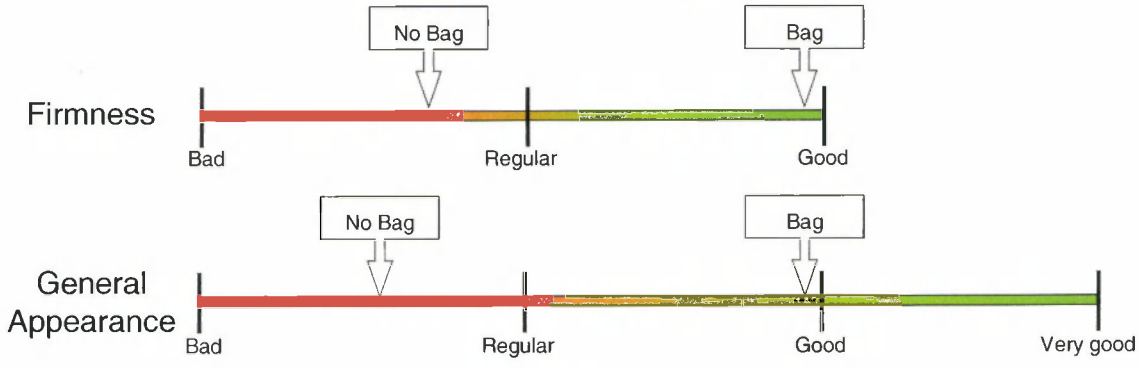


Figure 2: Firmness and general appearance of treatment 'bag'

- Brushed fruit had a regular to good general appearance where only washed fruit had a good to very good general appearance. The results a visualized in Figure 3.

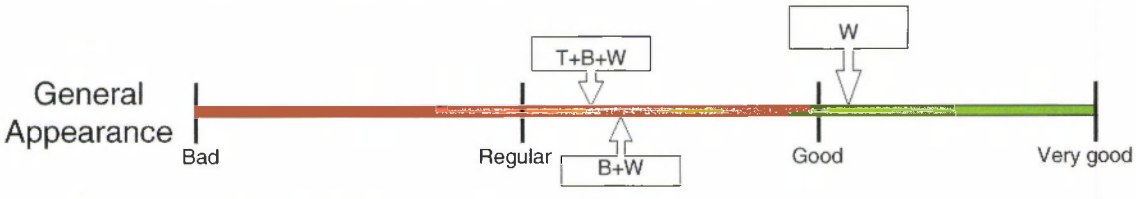


Figure 3: General appearance of treatment 'field'

Quality after retail phase

When we look at the data after the retail simulation we see that the damage that was introduced by the handling in the production chain worsened the subsidence and scars of the fruit. The means of the 3 different treatments are given in Table 3. The letters in the table show the level of significance. The least significant difference was 3.75.

Table 3: Means of Subsidence and Scars by treatment

Treatment	Subsidence and Scars
T+B+W	20.15 (a)
B+W	13.27 (b)
W	4.03 (c)

The treatment bag lowered the subsidence and scars considerably. Fruit that was packed in a bag had a mean of 10.5 and fruit that was packed without a bag had a mean of 22.8. So packing the fruit in bags reduced the problem with more then 50%. This is shown in Figure 4.

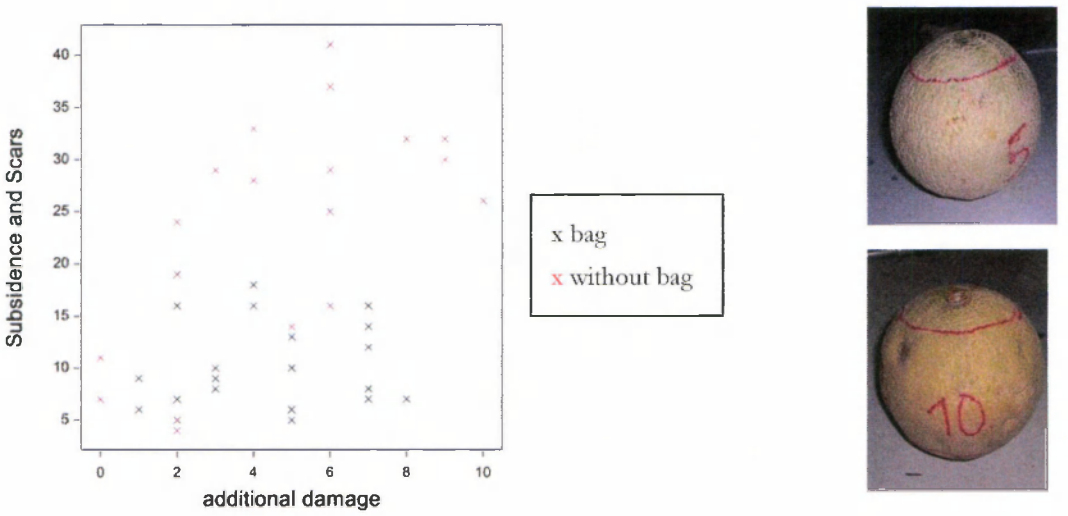


Figure 4: Handling damage (additional damage) against subsidence and scars by level of bags (melon 5 packed in bag, melon 10 packed without bag)

Pre-cooling had a positive effect on the general state and the condition of the melons, although the overall state of the melons was bad after the retail phase.
Pre-cooling in combination with bags gave the firmest melons. Results are shown in Figure 5.

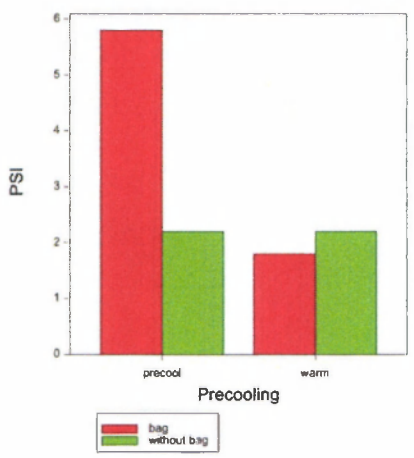


Figure 5: Mean PSI for pre-cooling with different levels of bags

Of all fruit that was transported from the field to the pack house (Treatment T+B+W) the position on the cart was noted (on top or at the bottom). Interestingly the position on the cart had an effect on PSI. The fruit on top had a mean PSI of 2.4 where the fruit at the bottom was more firm with a PSI of 5.6. The cause in difference is probably due to dehydration.

3.2.2.3 Field test 3

In the third field test CG RZ (size 9) where packed before tipping the fruit on the packaging belt and after tipping. One carton was packed with bag and one carton was packed without bag. The same quality indicators as in field test 2 was used (Color. Subsidence & Scars, Mold, Firmness and General Appearance).

From the data can be concluded that there was no effect of tipping or bags on mold formation nor on color development.

Tipping and no bag when packed had a significant negative effect on Firmness. Fruit that was packed in a bag before tipping was the firmest and fruit that was packed without a bag after tipping was the least firmest. This is also the case for the general appearance of the fruit. The results are visualized in Figure 6.

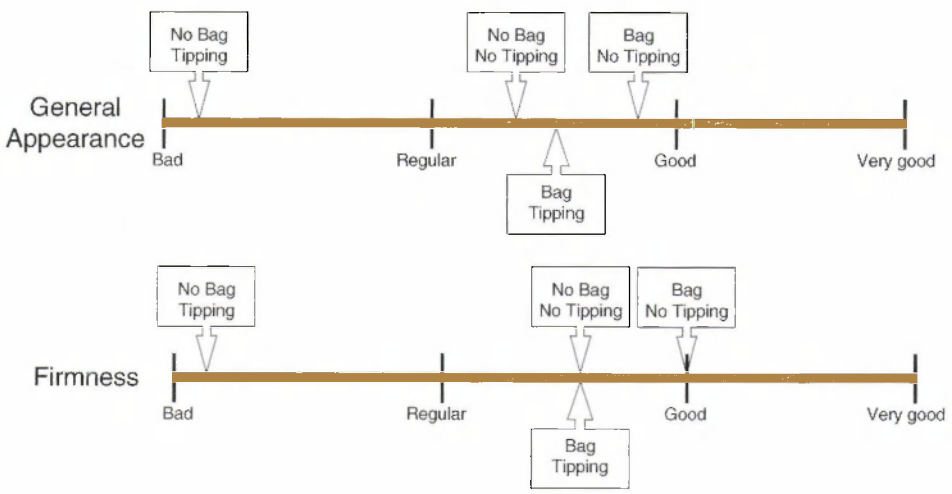


Figure 6: General appearance and firmness of combined treatments

4 Discussion

The overall quality of the Caribbean Gold RZ melon is influenced by many factors. In this chapter important factors are discussed.

- Climate:

Fruta Mundial said the growing season in Guatemala was colder and more humid than in other years. This might influence the development of the fruit. Under pressure from market demand fruit might have been harvested too early

- Harvest stage:

The stage of harvesting is important for the external maturity of the fruit. It's difficult to see if a melon is at the correct harvesting stage. Small indicators (crack in stem and background color) are the used indicators that a melon is sufficiently mature. The teams in the field clipping the melons must be trained and able to see the small indicators. Our impression is that maturity differences may bigger than is expected.

- Time and Temperature between harvest and cooling:

The time between harvest and drop off at the pack house can extend to more then three hours. In the meantime the fruit lays unprotected in the field or on the cart. Direct sunlight heats up the fruit subsequently the fruit dehydrates. All extra field heat must then later be removed in the cooling phase. This uses more energy, may last longer and the fruit anyway dehydrates more. We found a relation between dehydration and quality (bag vs. no bag and top of cart vs. bottom).

- Bruising and scars:

In the screening, only the damage from harvest till grading was counted. After grading the fruit makes more drops and rubs against each other (loading bins, unloading bins, full packaging belt). During all these processes the external surface of the melons damages more. The conclusion of field test 2 is that general appearance affected by damage. However this was only a small scale test.

- Pre-cooling

In the cold chain (and thus pre-cooling) the CG RZ is treated like a regular cantaloupe. These are most likely not the best temperature settings that are chosen for the CG RZ. The melon species CG RZ might be affected by low temperature decay and dehydration. The indication in field test 2 is that the fruit may be affected by dehydration. Pre-cooling was beneficial for general appearance and condition after the retail phase.

- Bags

In field test 2 the indication is that firmness, subsidence and scars and general appearance is negatively effected by packing without a bag. In the test only PE-film was used for the bags, there are several other materials that can be used. E.g. Xtend or perforated PE-film. No samples were taken from the atmosphere inside the bag to analyze gas composition.

- Field test 3

An unwanted difference in field test 3 is that the fruit is packed in 2 different temperatures. The room where the fruit was packed that wasn't tipped is conditioned at 4°C and the room where the fruit is packed that was tipped is conditioned at 9°C. This might effect the result of the test. Although general experience learns that the effect is minimal.

5 Conclusions

From the visit and the field tests the following conclusions can be drawn.

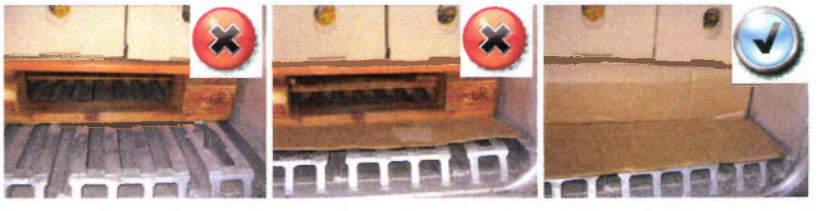
- The fruit stays to long in direct sunlight taking up field heat. This heat has to be removed later on in the process.
- The fruit is damaged significantly in the complete process. Starting already with the transport phase in the field and continuing through the whole further process. Bruising is mainly caused by the many drops of the fruits. The CG RZ seems to be sensitive for skin damage. This might be caused by high humidity during the growth season (less problems if humidity during cultivation is lower) and/or a immature harvesting stage (netting not fully developed).
- Damaged fruit shows a lower score on general appearance and more subsidence.
- Damaged fruit had 30% mold infections.
- After the retail phase almost all fruit showed mold infections.
- If the fruit picks up a lot of field heat (no shading) all this field heat has to be removed during pre-cooling, increasing the duration of the process, the costs and the dehydration.
- Field test 2 showed that fruit transported on top of the cart were softer than the fruit transported at the bottom.
- Field test 2 showed no indication of low temperature decay or dehydration effects by pre-cooling.
- There was no quality difference between pre-cooled and not pre-cooled fruit after storage.
- After the retail phase pre-cooling had a positive effect on general appearance and condition. In combinations with bags the melons had a higher PSI.
- Packing with bags gives firmer fruit and a better general appearance and lower count of subsidence and scars (field test 2 & 3).
- Tipping fruit out of the storage bin effects the fruit negatively on general appearance and firmness.
- The cartons do not fit the pallet, and the stacking is not on the strongest point of the cartons. Cartons may collapse and the weight of the load is on the fruit.
- Chimneys are made inside the pallet. The pallet volume is not optimally used (open spaces).
- The loading dock is not temperature controlled and the cushioning does not fit the reefer container. Warm (humid) air can enter the room and container condensate on the colder parts. If cartons take up moisture they lose strength.
- The end of the T-bar floor is not covered. This is an 'escape' route for the cold supply air. The air is not blown through the pallets but goes around. Especially in at the door end this may result in higher temperatures.

5.1 Unknown effects and fruit quality

The effect of harvesting stage (maturity) on fruit quality is not known.
The effect of different pre-cool temperatures on fruit quality is not known. In a simple field trial with pre-cooling was tested. This indicated no pre-cool effect after storage, but showed effect after the retail phase.
CG-RZ melons are sensitive for dehydration. Different approaches might be considered to prevent dehydration i.e. a different pre-cool method, different packaging material.
The optimal storage temperature for CG-RZ melons is not known.
The gas decomposition inside the bag is not known. Different O_2 and CO_2 levels may have good results on fruit quality.
The effect of condensation on the fruit surface on fruit quality is not known.

5.2 Recommendations

Harvest at the correct maturity stage.
Minimize time between harvest and processing at the packing house.
Minimize temperature between harvest and processing at the packing house, use shading!
Minimize transport and handling damage through the complete process.
Use bags in the cartons to pack the fruit.
Use cartons that fit the pallet.
Close connection between loading dock and container (or do not pre-cool the container).
Close T-bar floor and pallet opening when container is fully loaded.

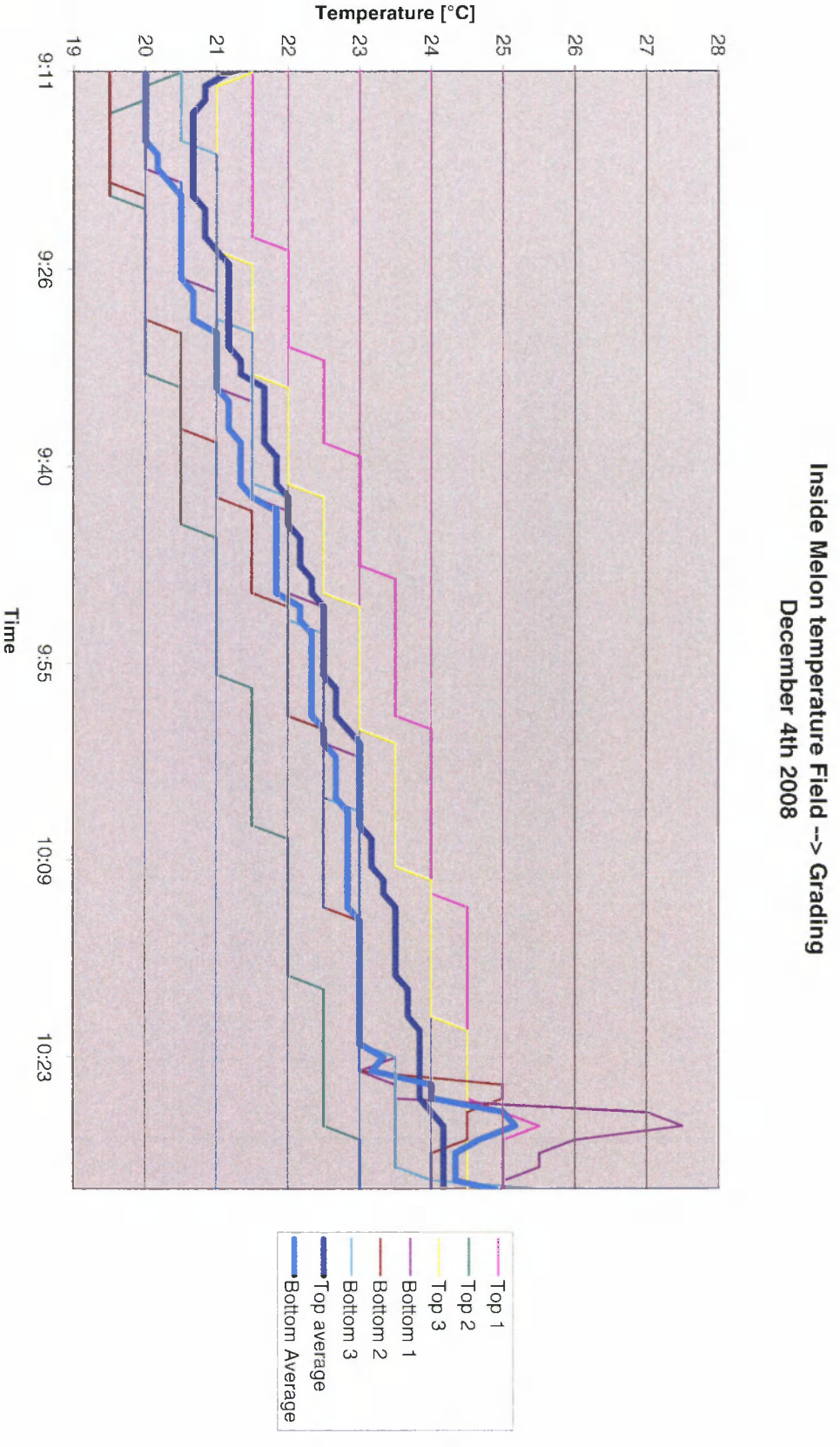


Pre-cooling: One can think of a system where not bins are pre-cooled, but packed pallets, preventing dehydration.

Acknowledgements

The author would like to thank Guillermo Castillo of Rijk Zwaan for his cooperation in this project. Thanks goes also to Fresh Quest and Fruta Mundial for their hospitality and openness.

Appendix 1 temperature of melons



Appendix 2 data field test 1

No. Melon	Field Test	position	initial damage	additional damage	total damage
1	T+B+W	bottom	1	7	8
2	T+B+W	bottom	2	3	5
3	T+B+W	bottom	2	2	4
4	T+B+W	bottom	0	5	5
5	T+B+W	bottom	1	3	4
6	T+B+W	bottom	3	10	13
7	T+B+W	bottom	4	6	10
8	T+B+W	bottom	2	8	10
9	T+B+W	bottom	1	2	3
10	T+B+W	bottom	1	4	5
11	T+B+W	top	1	1	2
12	T+B+W	top	2	7	9
13	T+B+W	top	2	4	6
14	T+B+W	top	2	7	9
15	T+B+W	top	3	5	8
16	T+B+W	top	3	6	9
17	T+B+W	top	1	4	5
18	T+B+W	top	1	9	10
19	T+B+W	top	2	9	11
20	T+B+W	top	1	3	4
21	B+W	n/a	3	1	4
22	B+W	n/a	7	5	12
23	B+W	n/a	4	8	12
24	B+W	n/a	2	7	9
25	B+W	n/a	3	7	10
26	B+W	n/a	1	2	3
27	B+W	n/a	3	4	7
28	B+W	n/a	1	5	6
29	B+W	n/a	3	1	4
30	B+W	n/a	3	3	6
31	B+W	n/a	3	4	7
32	B+W	n/a	2	2	4
33	B+W	n/a	1	0	1
34	B+W	n/a	3	2	5
35	B+W	n/a	4	2	6
36	B+W	n/a	5	6	11
37	B+W	n/a	5	6	11
38	B+W	n/a	3	5	8
39	B+W	n/a	5	6	11
40	B+W	n/a	1	0	1
41	W	n/a	0	0	0
42	W	n/a	3	3	6
43	W	n/a	3	0	3
44	W	n/a	1	1	2
45	W	n/a	1	1	2
46	W	n/a	0	0	0

No. Melon	Field Test	position	initial damage	additional damage	total damage
47	W	n/a	6	2	8
48	W	n/a	3	2	5
49	W	n/a	5	3	8
50	W	n/a	1	0	1
51	W	n/a	5	1	6
52	W	n/a	7	0	7
53	W	n/a	3	2	5
54	W	n/a	3	2	5
55	W	n/a	1	1	2
56	W	n/a	3	0	3
57	W	n/a	4	1	5
58	W	n/a	2	1	3
59	W	n/a	0	0	0
60	W	n/a	2	0	2

Appendix 3 data field test 2 after storage

Field Test	position	Pre-cooling	Bags	Green	Subsidence and Scars	Mold [0,1]	Firmness [0,2]	State General [0,3]
T+B+W	bottom	pre-cool	bag	0	0	0	2	2
T+B+W	bottom	pre-cool	bag	0	1	0	2	2
T+B+W	bottom	pre-cool	bag	0	1	0	2	2
T+B+W	bottom	pre-cool	bag	0	1	0	2	2
T+B+W	bottom	pre-cool	bag	1	1	0	1	1
T+B+W	bottom	pre-cool	no bag	1	6	0	1	1
T+B+W	bottom	pre-cool	no bag	0	13	0	0	0
T+B+W	bottom	pre-cool	no bag	0	8	1	1	1
T+B+W	bottom	pre-cool	no bag	0	8	1	1	1
T+B+W	bottom	pre-cool	no bag	0	9	0	1	1
T+B+W	top	pre-cool	bag	0	0	0	2	2
T+B+W	top	pre-cool	bag	0	2	0	2	2
T+B+W	top	pre-cool	bag	1	0	1	2	2
T+B+W	top	pre-cool	bag	0	2	0	2	2
T+B+W	top	pre-cool	bag	1	0	0	2	2
T+B+W	top	pre-cool	no bag	0	9	0	1	1
T+B+W	top	pre-cool	no bag	0	10	0	1	0
T+B+W	top	pre-cool	no bag	0	11	1	0	0
T+B+W	top	pre-cool	no bag	0	10	1	0	0
T+B+W	top	pre-cool	no bag	0	11	1	0	0
B+W	n/a	warm	bag	0	0	0	2	2
B+W	n/a	warm	bag	0	0	0	2	2
B+W	n/a	warm	bag	0	3	0	2	2
B+W	n/a	warm	bag	0	2	0	2	2
B+W	n/a	warm	bag	0	2	0	2	2
B+W	n/a	warm	bag	1	1	0	2	2
B+W	n/a	warm	bag	0	4	0	2	2
B+W	n/a	warm	bag	0	2	0	2	2
B+W	n/a	warm	bag	0	4	0	2	2
B+W	n/a	warm	bag	0	1	0	2	2
B+W	n/a	warm	no bag	0	9	0	2	1
B+W	n/a	warm	no bag	0	9	0	2	1
B+W	n/a	warm	no bag	0	5	0	1	1
B+W	n/a	warm	no bag	0	6	0	0	1
B+W	n/a	warm	no bag	0	5	0	0	0
B+W	n/a	warm	no bag	0	9	0	0	0
B+W	n/a	warm	no bag	0	9	0	0	0
B+W	n/a	warm	no bag	0	5	0	1	1

Field Test	position	Pre-cooling	Bags	Green	Subsidence and Scars	Mold [0,1]	Firmness [0,2]	State General [0,3]
B+W	n/a	warm	no bag	0	9	0	1	1
B+W	n/a	warm	no bag	0	4	0	1	1
W	n/a	pre-cool	bag	0	0	0	2	2
W	n/a	pre-cool	bag	0	3	0	2	2
W	n/a	pre-cool	bag	0	3	0	2	2
W	n/a	pre-cool	bag	0	0	0	2	3
W	n/a	pre-cool	bag	0	0	0	2	2
W	n/a	pre-cool	bag	0	0	0	2	3
W	n/a	pre-cool	bag	0	2	0	2	2
W	n/a	pre-cool	bag	0	2	0	1	1
W	n/a	pre-cool	bag	0	3	0	2	2
W	n/a	pre-cool	bag	0	0	0	2	3
W	n/a	warm	bag	0	0	0	2	2
W	n/a	warm	bag	0	0	0	2	2
W	n/a	warm	bag	0	0	0	2	2
W	n/a	warm	bag	0	0	0	2	2
W	n/a	warm	bag	0	0	0	2	2
W	n/a	warm	bag	0	0	0	1	1
W	n/a	warm	bag	0	1	0	2	2
W	n/a	warm	bag	0	0	0	2	2
W	n/a	warm	bag	0	1	0	2	2
W	n/a	warm	bag	0	1	0	2	3

Appendix 3 data field test 2 after retail phase

Field Test	position	Pre-cooling	Bags	Subsidence and Scars	Mold [0,1]	State General [0,4]	Condition [0,4]	Brix	PSI
T+B+W	bottom	pre-cool	bag	12	1	2	2	10	8.5
T+B+W	bottom	pre-cool	bag	8	1	2	2	11	10
T+B+W	bottom	pre-cool	bag	7	1	1	1	8.6	7.5
T+B+W	bottom	pre-cool	bag	13	1	2	2	10	9
T+B+W	bottom	pre-cool	bag	9	0	3	3	13	7
T+B+W	bottom	pre-cool	without bag	26	0	1	1	11	3
T+B+W	bottom	pre-cool	without bag	25	1	1	1	11	1.5
T+B+W	bottom	pre-cool	without bag	32	1	1	1	10.8	5
T+B+W	bottom	pre-cool	without bag	24	0	2	2	9	2.5
T+B+W	bottom	pre-cool	without bag	18	1	0	0	10	2
T+B+W	top	pre-cool	bag	6	1	3	3	13.4	3
T+B+W	top	pre-cool	bag	14	1	1	1	9	1
T+B+W	top	pre-cool	bag	18	1	2	2	11	2
T+B+W	top	pre-cool	bag	8	1	3	3	10.6	4.5
T+B+W	top	pre-cool	bag	6	0	4	4	9	5.5
T+B+W	top	pre-cool	without bag	41	0	1	1	6	3
T+B+W	top	pre-cool	without bag	33	1	1	1	12	0
T+B+W	top	pre-cool	without bag	32	1	1	1	10	1.5
T+B+W	top	pre-cool	without bag	30	0	2	2	9.8	3
T+B+W	top	pre-cool	without bag	29	1	1	1	10.4	0.5
B+W	n/a	warm	bag	9	1	1	1	9	1.5
B+W	n/a	warm	bag	10	1	2	1	11.4	1
B+W	n/a	warm	bag	7	1	2	1	11	4.5
B+W	n/a	warm	bag	7	1	1	1	11.5	1
B+W	n/a	warm	bag	16	1	1	1	9	1
B+W	n/a	warm	bag	16	1	0	0	7	2
B+W	n/a	warm	bag	16	1	0	0	9	3
B+W	n/a	warm	bag	5	1	0	0	12	1
B+W	n/a	warm	bag	9	1	0	0	9	1
B+W	n/a	warm	bag	10	1	1	1	8	2
B+W	n/a	warm	without bag	28	1	1	1	7	2.5
B+W	n/a	warm	without bag	19	1	1	1	6.5	3.5
B+W	n/a	warm	without bag	11	1	2	1	14	1
B+W	n/a	warm	without bag	4	1	1	1	9.4	1.5
B+W	n/a	warm	without bag	5	1	1	1	7	2
B+W	n/a	warm	without bag	37	1	0	0	7	2.5
B+W	n/a	warm	without bag	29	0	0	0	10	2

Field Test	position	Pre-cooling	Bags	Subsidence and Scars	Mold [0,1]	State General [0,4]	Condition [0,4]	Brix	PSI
B+W	n/a	warm	without bag	14	1	1	1	8	2.5
B+W	n/a	warm	without bag	16	0	2	2	12	2
B+W	n/a	warm	without bag	7	1	2	2	9	2.5
W	n/a	pre-cool	bag	4	1	1	1	8	4
W	n/a	pre-cool	bag	5	1	1	1	9	2.5
W	n/a	pre-cool	bag	5	1	1	1	9	3.5
W	n/a	pre-cool	bag	3	1	1	1	10	3
W	n/a	pre-cool	bag	5	1	1	1	9	5.5
W	n/a	pre-cool	bag	4	1	1	1	9	5.5
W	n/a	pre-cool	bag	5	1	1	1	11	2.5
W	n/a	pre-cool	bag	5	1	1	1	7	5
W	n/a	pre-cool	bag	2	1	2	1	9	3.5
W	n/a	pre-cool	bag	2	1	1	1	14	2.5
W	n/a	warm	bag	3	1	2	2	10	0
W	n/a	warm	bag	10	1	1	1	11.6	3
W	n/a	warm	bag	1	1	3	3	13	4.5
W	n/a	warm	bag	5	1	2	2	8	4.5
W	n/a	warm	bag	5	1	1	1	11.2	3.5
W	n/a	warm	bag	2	1	3	3	9.8	1.5
W	n/a	warm	bag	8	1	1	1	11	1.5
W	n/a	warm	bag	4	1	1	1	12	1
W	n/a	warm	bag	4	1	2	2	9.4	2.5
W	n/a	warm	bag	1	1	3	3	11	1.5

Appendix 4 data field test 3

Field Test	Pre-cooling	Bags	Green [0,1]	Subsidence and Scars	Mold [0,1]	Firmness [0,3]	State General [0,3]
no tipping	pre-cool	no bag	0	5	0	2	1
no tipping	pre-cool	no bag	0	4	0	2	2
no tipping	pre-cool	no bag	0	3	0	2	2
no tipping	pre-cool	no bag	0	3	0	2	2
no tipping	pre-cool	no bag	0	2	1	1	1
no tipping	pre-cool	no bag	0	1	0	2	2
no tipping	pre-cool	no bag	0	3	0	1	1
no tipping	pre-cool	no bag	0	9	0	1	1
no tipping	pre-cool	no bag	0	2	0	2	1
no tipping	pre-cool	bag	0	1	0	2	2
no tipping	pre-cool	bag	0	4	0	2	2
no tipping	pre-cool	bag	0	6	0	2	2
no tipping	pre-cool	bag	0	4	0	2	2
no tipping	pre-cool	bag	0	2	1	2	2
no tipping	pre-cool	bag	0	3	0	2	2
no tipping	pre-cool	bag	0	0	0	3	3
no tipping	pre-cool	bag	0	2	0	1	1
no tipping	pre-cool	bag	0	1	0	2	1
tipping	pre-cool	bag	0	0	0	2	2
tipping	pre-cool	bag	0	1	0	2	2
tipping	pre-cool	bag	0	6	0	2	2
tipping	pre-cool	bag	0	4	0	2	2
tipping	pre-cool	bag	0	5	1	2	2
tipping	pre-cool	bag	0	2	0	1	2
tipping	pre-cool	bag	0	5	0	2	1
tipping	pre-cool	bag	0	5	0	1	1
tipping	pre-cool	bag	0	2	0	2	1
tipping	pre-cool	no bag	0	20	0	0	0
tipping	pre-cool	no bag	0	8	0	0	0
tipping	pre-cool	no bag	0	5	0	1	1
tipping	pre-cool	no bag	0	6	0	0	0
tipping	pre-cool	no bag	0	6	1	0	0
tipping	pre-cool	no bag	0	7	0	0	0
tipping	pre-cool	no bag	0	4	0	0	0
tipping	pre-cool	no bag	0	6	0	0	0
tipping	pre-cool	no bag	0	15	0	0	0

