Fifth Quest Regular Trial Shipment

Melons from Brazil to the Netherlands and the U.K.

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Abstract

The “Quest regular” system has been developed to reduce power consumption of reefer containers. The Quest Regular concept and corresponding CCPC software was tested in a (fifth) real-life shipment of melons from Brazil to the Netherlands and the U.K. in September 2006. The goal of the trial shipment was to test the software and compare the power usage, temperature distribution and product quality of two Quest test containers to those of two reference containers, which were shipped simultaneously at original settings.

Mean savings are 68%. When accounting for the additional energy consumption due to the (erroneously activated) dehumidification, the estimated savings are 44% and -17% for set 1 and set 2 respectively.

The supply air of the Quest containers fluctuates in time, but with such a high frequency, that the fluctuations are hardly visible in the carton temperature data (measured with a 30 min period).

During Quest Regular Mode, the minimum supply temperature mostly does not reach supply setting, but stops at about 0.5°C above setpoint. Adaptation of the field software, after comparable issues for mandarin and apple, apparently did not help (enough) to prevent same for these melon shipments.

Overall, carton temperatures in the Quest container were satisfactory and reasonably close to the setpoint. The Quest container cartons were 0.3°C further from setpoint then the reference, while the bandwidth was 0.1°C smaller.

No chilling injury indications were found. Product quality was not affected by the container, pallet position or layer. Also, no relation was found between the average temperature and product quality. This indicates that the Quest regime did not change quality output compared to normal regime.
Acknowledgements

This fifth real-life Quest trial was largely organized and performed by Maersk Line. Most of the data and information in this report was provided by Maersk employees. We especially would like to thank Mr. Lindhardt and Mr. Nielsen of Maersk’s Centre Reefer Management, Mr Hofmann of Maersk’s Reefer Management Great Britain, Mr Selsig of Maersk’s Claims Rotterdam and Mr. Barfod and Mr. de Castro Alves of Maersk’s Reefer Operations - South America.

We also thank Carrier Transicold for providing the necessary CCPC software for the trial and the unit data-files that were made from the unit downloads. We especially would like to thank Mr. Griffin, Mr. Dudly, Mr. Duraisamy, Mr. McIntosh, Mr. Whyte, Mr. Smith, Mr. Bazan and Mr. Bretherton.

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Finally, our thanks go to Sallouti, 4Fruit, Hage Intl., Levarht and International Produce, whose fruit was transported and who made quality inspection possible before and after transport.
Contents

Abstract 3
Acknowledgements 4

1 Introduction 7

2 Material and methods 8
  2.1 Product 8
  2.2 Packaging and stowage 8
  2.3 Unit settings 8
  2.4 Voyage schedule 9
  2.5 Unit and climate measurements 10
  2.6 Quality measurements 11

3 Temperatures 12
  3.1 Temperature readings at the start of the trip 12
  3.2 Temperature readings during pull down 12
  3.3 Supply air temperatures during Quest Regular Mode 12
  3.4 Temperature readings during Quest Regular Mode 14
  3.5 Temperatures at the end of the trip 16

4 Power Consumption 19

5 Evaluation of fruit quality 21
  5.1 General remarks 21
  5.2 External quality 22
  5.3 Internal quality 22
  5.4 Average temperature and quality 23

6 Conclusions 24
  6.1 Power savings 24
  6.2 Temperatures 24
  6.3 Product quality 24

References 25

Appendix I: Ambient conditions between Brazil and Great Britain 26
Appendix II: Settings and dehumidification during the trip 27
Appendix III: Carton temperatures 28
Appendix IV: Unit temperature readings as a function of time 30
Appendix V: Snapshot pictures of carton temperature readings 34
Appendix VI: Ambient temperatures 38

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Appendix VII: Unit activity graphs
1 Introduction

The “Quest regular” system has been developed to reduce power consumption of reefer containers. As a follow-up of the first real-life Quest trial with mangoes and the second trial with apples and mandarins, it has been tested for bananas, melons and pineapples in September 2006. In order to exactly determine the amount of power reduction, a comparison was made with two standard controlled reefer containers. All four 40 ft. containers were loaded with melons and were transported on the same vessel (Lexa Maersk). The shipment was from Brazil (Pecém) to the Netherlands (Rotterdam) and the U.K. (Thamesport). The transport time was 10 days to Rotterdam and 11 days to Thamesport.

The test containers (MWCU6752504 Melon test 1 and PONU4756985 Melon test 2) were equipped with and controlled by the “Quest Regular” software, also referred to as CCPC (Compressor-Cycle Perishable Cooling). The containers MWCU6810262 Melon ref 1 and PONU4754914 Melon ref 2 served as reference containers. During the shipment power consumption of all containers was measured using externally added KWH-meters. The temperature distribution was measured using 18 sensors per container and logging the actual temperature every 30 minutes. Fruit samples for quality evaluation (6 cartons) were taken from 5 pallets in both containers test 1 and ref 2 (see scheme and location of the temperature sensors). All of these test cartons contained a temperature sensor (Tiny Tag) to be able to compare the temperature distributions of both containers. With these readings it would be possible to determine correlations between local temperatures and quality development of the fruits. Upon arrival in the Netherlands a first quality inspection of the melons was carried out. The quality evaluation was extended by a shelf life treatment of the test samples using the experimental facilities of AFSG in Wageningen, The Netherlands.

A precise quality evaluation was necessary as the Quest Regular mode operation allows the supply air to have a low value during specific interval times. This value is lower than the value that is commonly considered a chilling temperature. The idea behind this is that chilling will be avoided by cycling, as the supplied air is only on this low level for short periods. Product temperature and internal metabolic processes do not follow these quick changes of the temperature settings i.e. chilling will not occur. This hypothesis was tested successfully for several commodities before but not for Galia melon. The energy saving method is only of value when product i.e. melon quality is not harmed by it.
2 Material and methods

2.1 Product
The melon variety was Galia in various sizes. The apples originated from one grower: J.S. Sallouti from Morrosó in Brasil. The initial temperature of the melon was just above 7°C.

2.2 Packaging and stowage
The melons are packed in cardboard boxes, with trays and covered with Xtend bags. The box size is 300x400 mm, stacked 15 boxes high (10 on a layer). In total 4 containers with 3000 cartons are packed, placed on 20 pallets. The pallets used were wooden industrial pallets size 1200x1000 mm. 20.5 pallets were fitted in the container cross stacked (see also Figure 5).

2.3 Unit settings
The containers used were fitted with Carrier Thinline refrigeration units. The CCPC program (v. 9576) was installed on all units, using a microlink 3 card or a microlink 2/3 adapter. The reference containers were running in normal mode with settings as usual for Galia Melon. For these, the CCPC software was only used to enable additional data logging. The Quest containers were running in CCPC mode.

The reference container settings were:
- Supply setpoint 7.2 °C = 45.0 F
- Fan setting High
- Vent setting 15 m³/hr

The CCPC settings were:
- Supply setpoint 5.2 °C = 41.4 F
- Return Air Pulldown Low Limit 7.2 °C = 45.0 F
- Return Air Low Limit 7.2 °C = 45.0 F
- Return Air High Limit 8.2 °C = 46.8 F
- Fan setting Alternating
- Vent setting 15 m³/hr
Defrost interval: was set to automatic and Humidity, Dehumidification and Bulb Mode were all set to OFF.

2.4 Voyage schedule
On September 12th till September 14th the containers were loaded with melons. Subsequently, the containers were taken to the harbour of Pecém. The setup is shown in Table 2.

<table>
<thead>
<tr>
<th>Container nr</th>
<th>Setup mode</th>
<th>Stuffing date</th>
<th>Commodity</th>
<th>Grower</th>
</tr>
</thead>
<tbody>
<tr>
<td>PONU 475 491</td>
<td>NORMAL (ref2)</td>
<td>14/9/2006</td>
<td>Melon</td>
<td>J.S. Sallouti</td>
</tr>
<tr>
<td>MWCU 675 250</td>
<td>CCPC (test1)</td>
<td>12/9/2006</td>
<td>Melon</td>
<td>J.S. Sallouti</td>
</tr>
<tr>
<td>PONU 475 698</td>
<td>CCPC (test2)</td>
<td>14/9/2006</td>
<td>Melon</td>
<td>J.S. Sallouti</td>
</tr>
<tr>
<td>MWCU 681 026</td>
<td>NORMAL (ref1)</td>
<td>13/7/2006</td>
<td>Melon</td>
<td>J.S. Sallouti</td>
</tr>
</tbody>
</table>

All containers were loaded to the vessel (Lexa Maersk) during the night of September 17th.

Figure 3 Map of loading and departure locations
The containers arrived in Rotterdam (The Netherlands) on September 27th and in Thamesport (U.K.) on September 28th. Figure 16 and Figure 17 in the appendix depict the mean temperature and relative humidity in September for such a trip.

2.5 Unit and climate measurements
External KWh meters were attached to all units. The CCPC software installed on the containers included additional data logging, storing elaborate unit information every hour. Temperatures were measured by 4 USDA probes and 18 Tiny tags inside the containers. In order to measure the temperature reaction of the fruit to the software system the Tiny Tags data loggers were placed next to the fruit to the sidewall of each carton. Data recording had been pre-set for every 30 minutes. Such instruments were placed in 6 pallets at the bottom and ¾ in height.

Figure 5 shows the stowage of the pallets in the containers. The yellow marked pallets were fitted with temperature, relative humidity and gas decomposition sensors. These are also the pallets from which samples for shelf live testing were taken. The green marked pallets were fitted with USDA-probes (on the bottom layer), measuring product temperature. Probe 1 was installed in pallet 1, Probe 2 was installed in pallet 2 and Probe 3 and 4 were installed in pallet 19 and 20.

![Figure 5 Container layout](image)
2.6 Quality measurements

Melon pallets contained 15 layers of boxes containing 5 or 6 Galia melons. From two Quest containers 6 boxes were taken as sample boxes, from one Reference container 12 sample boxes were taken. The sample boxes were located on:

- Pallet 1, layer 1 (and 2)
- Pallet 2, layer 1 (and 2)
- Pallet 11, layer 1 (and 2)
- Pallet 11, layer 12 (and 13)
- Pallet 16, layer 12 (and 13)
- Pallet 18, layer 12 (and 13)

The layers between brackets refer to 6 extra boxes from the Reference container.

The melons were transported from the place of delivery in Rotterdam to Wageningen in a cooled van (7°C) and were subsequently stored at 18°C/75% relative humidity (RH) as a simulation of shelf life. Quality of melons was scored by visual examination on day 0, day 6 and day 8 of the shelf life simulation. On day 12 melons were tasted and Brix value was measured.
3 Temperatures

Figure 6 and Figure 7 show the Tiny Tag data for the coolest and warmest cartons, as well as the mean temperature of all cartons, for the more or less stable-temperatures stage of the shipment. In the first 120 hours of the shipment the temperatures are still in pull-down (see Figure 20 and Figure 21 in the appendix). Figure 6 and Figure 7 present the most interesting carton temperature readings. The complete carton temperature readings are shown in Figure 18 and Figure 19 in the appendix. Time instance Sept. 15\textsuperscript{th} 2006 00:00 is defined as $t=0$. To get a good impression of the spatial distributions of the carton temperatures and how these change in time, see the movies on the accompanying cd.

3.1 Temperature readings at the start of the trip
The initial temperature readings of the cartons in the test and reference containers are comparable, mostly between 7 and 25°C (see Figure 18 and Figure 19 in the appendix). Especially for test 2 and ref 2 the spread is large.

3.2 Temperature readings during pull down
Pull down of ref 2 and test 2 is performed at 5.6 and 5.0°C instead of 7.2°C (see Table 10 in the appendix). This is also visible in the carton readings, e.g. in ref 2 the coldest carton (Figure 7b) is about 6.8 °C. This is 0.4 °C below supply air setpoint.

Some initial temperatures lie relatively far from the setpoint of 7.2 °C. The cartons are cooled down to about 7.2 °C. After 120 h (5 days) the major part of the pull-down has passed by, although in all containers the warmest cartons remain in pull-down during the whole trip (Figure 6 and Figure 7).

During the first 2 days CCPC Mode was turned off on unit Quest test 2 and the unit was (mistakably) set to cool continuously on the low Quest setpoint of 5.2°C. This causes an additional cool down of the product during the first 50 hours, which is not part of normal Quest Regular operation (see Figure 18a: it does not happen in test 1). This was corrected in the harbour, just before loading to the vessel. The coldest carton temperatures thus pull up again during day 3.

3.3 Supply air temperatures during Quest Regular Mode
During Quest Regular Mode, the minimum supply temperature mostly does not reach supply setting, but stops at about 5.8°C instead of 5.2°C for test 1 and at about 5.5°C instead of 5.2°C for test 2 (see Figure 22 to Figure 25 in the appendix). The compressor on time is about 10 minutes, which should be long enough to reach setpoint. Adaptation of the field software, after comparable issues for mandarin and apple, apparently did not help (enough) to prevent same for these melon shipments.
Figure 6  Temperature readings of Tiny Tags in cartons, coolest (-) and warmest (-) carton, as well as mean temperature for all cartons (-), for both Melon 1 containers

Figure 7  Temperature readings of Tiny Tags in cartons, coolest (-) and warmest (-) carton, as well as mean temperature for all cartons (-), for both Melon 2 containers
3.4 Temperature readings during Quest Regular Mode

The supply air of the Quest containers fluctuates in time, but with such a high frequency, that the fluctuations are hardly visible in the carton temperature data (measured with a 30 min period).

The temperature data for the Quest Regular period (Sept. 20th until Sept. 27th, t=120 – 288 h) have been summarized in Table 3 through 0. The tables contain information on the temperatures of the coolest and warmest cartons as well as the mean temperature of all cartons combined.

First of all, the deviation from the given setpoint is important (see column 3 of Table 7). The mean carton temperature of the Quest containers is 8.1 °C. The mean carton temperature of the reference containers is 7.8 °C. Thus, the Quest containers are 0.3°C further from setpoint of 7.2°C than the reference containers.

Secondly, the maximum bandwidth of the carton temperatures is considered (see Table 3, column 2 and 4). Looking at the lowest and highest temperatures measured in the cartons, the maximum temperature difference between the coolest and warmest cartons was 2.3°C in the Quest containers and 3.2°C in the reference containers. Thus, in the most extreme situation, the Quest containers had a 0.9°C smaller maximum temperature bandwidth than the reference containers.

Thirdly, the mean bandwidth of the carton temperatures is considered (see 0, column 2 and 4). Looking at the mean of the carton temperatures in time, the temperature difference between the coolest and warmest cartons was 1.9 °C in the Quest containers and 2.0 °C in the reference containers. Thus, on average, the Quest containers had a 0.1°C smaller temperature bandwidth than the reference container.

Fourthly, the time-averaged deviation of the coolest carton from the given setpoint is important (see column 2 of 0 and Table 7). The coolest cartons of the Quest containers were 0.1 °C above setpoint. The coolest cartons of the reference containers are 0.1°C above setpoint. Thus, the coolest cartons of the Quest containers are just as close to the setpoint as the reference containers.

Finally, the time-averaged deviation of the warmest cartons from the given setpoint is important (see column 4 of 0 and Table 7). The warmest cartons of the Quest containers are 2.0 °C above setpoint. The warmest cartons of the reference containers are 2.1°C above setpoint. Thus, the warmest cartons of the Quest containers are 0.1°C closer to the setpoint than the reference containers.
Table 3 The ranges of the minimum, maximum and mean carton temperature readings (from July 18th 00:00 to August 2nd 00:00 for melon)

<table>
<thead>
<tr>
<th></th>
<th>min carton T (°C)</th>
<th>mean carton T (°C)</th>
<th>max carton T (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quest container 1</td>
<td>7.7 to 7.8</td>
<td>8.5 to 8.8</td>
<td>9.6 to 10.4</td>
</tr>
<tr>
<td>Quest container 2</td>
<td>6.9 to 6.9</td>
<td>7.5 to 7.7</td>
<td>8.0 to 8.8</td>
</tr>
<tr>
<td>reference cont. 1</td>
<td>7.7 to 7.9</td>
<td>8.1 to 8.4</td>
<td>9.2 to 10.2</td>
</tr>
<tr>
<td>reference cont. 2</td>
<td>6.6 to 6.8</td>
<td>7.2 to 8.1</td>
<td>7.9 to 10.5</td>
</tr>
</tbody>
</table>

Table 4 The mean of the minimum, maximum and mean carton temperature readings

<table>
<thead>
<tr>
<th></th>
<th>mean min carton T (°C)</th>
<th>mean mean carton T (°C)</th>
<th>mean max carton T (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quest container 1</td>
<td>7.7</td>
<td>8.6</td>
<td>10.0</td>
</tr>
<tr>
<td>Quest container 2</td>
<td>6.9</td>
<td>7.6</td>
<td>8.4</td>
</tr>
<tr>
<td>reference cont. 1</td>
<td>7.8</td>
<td>8.2</td>
<td>9.7</td>
</tr>
<tr>
<td>reference cont. 2</td>
<td>6.7</td>
<td>7.5</td>
<td>8.8</td>
</tr>
</tbody>
</table>

Table 5 The deviations from setpoint for the minimum, maximum and mean carton temperature readings (= Table 3 – setpoint).

<table>
<thead>
<tr>
<th></th>
<th>dev min carton T (°C)</th>
<th>dev mean carton T (°C)</th>
<th>dev max carton T (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quest container 1</td>
<td>0.5 to 0.6</td>
<td>1.3 to 1.6</td>
<td>4.4 to 3.2</td>
</tr>
<tr>
<td>Quest container 2</td>
<td>-0.3 to -0.3</td>
<td>0.3 to 0.5</td>
<td>0.8 to 1.6</td>
</tr>
<tr>
<td>reference cont. 1</td>
<td>0.5 to 0.7</td>
<td>0.9 to 1.2</td>
<td>2.0 to 3.0</td>
</tr>
<tr>
<td>reference cont. 2</td>
<td>-0.6 to -0.4</td>
<td>0.0 to 0.9</td>
<td>0.7 to 3.3</td>
</tr>
</tbody>
</table>

Table 6 The deviations from setpoint for the mean of the minimum, maximum and mean carton temperature readings (= 0 – setpoint).

<table>
<thead>
<tr>
<th></th>
<th>dev mean min carton T (°C)</th>
<th>dev mean mean carton T (°C)</th>
<th>dev mean max carton T (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quest container 1</td>
<td>0.5</td>
<td>1.4</td>
<td>2.8</td>
</tr>
<tr>
<td>Quest container 2</td>
<td>-0.3</td>
<td>0.4</td>
<td>1.2</td>
</tr>
<tr>
<td>reference cont. 1</td>
<td>0.6</td>
<td>1.0</td>
<td>2.5</td>
</tr>
<tr>
<td>reference cont. 2</td>
<td>-0.5</td>
<td>0.3</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Table 7 The difference in (absolute) deviation from setpoint for the Quest container compared to the reference container, for the coolest, mean and warmest carton

<table>
<thead>
<tr>
<th></th>
<th>ΔT coolest carton (°C)</th>
<th>ΔT mean carton (°C)</th>
<th>ΔT warmest carton (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ref 1] - [Quest 1]</td>
<td>+0.1</td>
<td>-0.4</td>
<td>-0.3</td>
</tr>
<tr>
<td>[ref 2] - [Quest 2]</td>
<td>+0.2</td>
<td>-0.1</td>
<td>+0.4</td>
</tr>
</tbody>
</table>
Overall, carton temperatures in the Quest container were satisfactory and reasonably close to the setpoint. The Quest container cartons were 0.3°C further from setpoint, while the bandwidth was 0.1°C smaller. The coolest cartons were just as close and the warmest cartons 0.1°C closer to the setpoint.

Pulp temperature USDA readings lie between 7.7 and 8.5°C in the reference containers and between 7 and 9.7°C in the test containers see Figure 22 through Figure 25 in the appendix.

3.5  **Temperatures at the end of the trip**
Figure 8 and Figure 9 show a snapshot of the carton temperatures near the end of the trip. They show that carton temperatures of the Quest containers lie a little further from setpoint than in the reference containers. Furthermore Figure 8 and Figure 9 give an indication of the temperature distributions over the various locations inside the containers.
Figure 8  Tiny Tag readings of the carton temperatures near the end of the trip, on Sept. 27th '06 00:00, Melon 1.
Figure 9  Tiny Tag readings of the carton temperatures near the end of the trip, on Sept. 27th '06 00:00, Melon 2.
4 Power Consumption

Power consumption data were read from the kWh meters by Maersk employees twice a day during the sea voyage, see Figure 10. Time axis is such that $t = 0$ starts at September 17th 2006 18:00.

The reference containers used 2274 and 1427 kWh in 216 hour, a mean power usage of 10.5 and 6.6 kW. The Quest container used 543 and 580 kWh in 216 h, a mean power usage of 2.5 and 2.7 kW, which is 76 and 59% less compared to the reference containers. The power and savings per day are shown in Figure 11. Mean savings are 68%.

Although at the start of the trip dehumidification was set OFF, the melon reference containers have dehumidification energy readings. The mean dehumidification energy in the power calculation period above is 3.6 kW for ref 1 and 2.6 kW for ref 2. When subtracting the dehumidification energy consumption, the reference containers had a mean power usage of 6.9 and 4.0 kW. Another factor to be taken into account is the additional cooling effort due to the dehumidification heating. This is approximately 66% of the heating effort. When also subtracting the estimated additional cooling effort, the reference containers had a mean power usage of 4.5 and 2.3 kW. Savings are then 44% and -17% respectively. Mean savings are then 14%.

The power savings are largely due to the periods that the compressor is turned off during cycling, the length of which can be seen in Figure 32 through Figure 34 in the appendix. (For comparison, also the active hours and defrost time of the units are shown.) Compressor off time intervals last approximately 15 - 30 minutes, about 1.5 – 3 times as long as the compressor-on time intervals. The compressor off periods become somewhat shorter when ambient temperature is higher. Other factors of influence are defrost intervals, the reduced fan speed during compressor-off time intervals and the somewhat reduced amount of ventilation during low fan speed/compressor off periods.

Defrost setting is AUTO, leaving the unit to learn from its measurement data how often a defrost action is necessary. Both reference units defrost about once a day, whereas the test containers defrost period increases to about once every 3 days. The defrost actions take approximately 15 minutes. These small values indicate that little ice was present on the coil. The
reduced amount of defrost actions for the Quest containers is due to the reduction in compressor run hours (approximately 1/3).
5 Evaluation of fruit quality

5.1 General remarks
At arrival all melons were of good quality. Melons were firm and showed no signs of ripening or bruising. Some melons displayed small brown spots on the peel, which did not show further development. Spots were visible on melons from the three different containers. Brix values (measured after 12 days of shelf life) were very low, which indicates that the melons were harvested while immature.

![Figure 12: Starting quality](image)

![Figure 13: Small brown spots](image)

Available samples:
- Reference container: 12 boxes, each box contained 5 melons of uniform grade
- Quest 1 container: 6 boxes, each box contained 5 melons of uniform grade
- Quest 2 container: 6 boxes, 3 boxes contained each 5 melons of uniform grade; 3 boxes contained each 6 smaller melons of uniform grade

Codes on the boxes revealed the following:
- all melons were picked in week 37 (but on different days)
- melons were from the same farm/field (but from different sections)
- melons were handled by the same packer/packing machine
- all melons in reference container and Quest 1 container were from **first** harvest
- all melons in Quest 2 container were from **second** harvest

Based on above observations, **melons from Quest 2 container were not considered representative as Quest 2 contained melons from 1) a different harvest period and 2) two different grades.**
5.2 External quality
During shelf life melons showed rot development and the severity was scored. Rot development progressed from the appearance of light brown patches onto dark-brown soft sunken lesions. When patches were clearly visible by eye, fruits were scored as “affected”. Statistical analysis (ANOVA) was done on observations of rot on day 8. No effect was found due to the container or the layer.

![Figure 14 Rot development](image1)
![Figure 15 Severe Rot](image2)

5.3 Internal quality
Brix value was measured on day 12; statistical analysis (ANOVA) was done on Brix data. There were no statistical differences in Brix values between containers and layers. Brix values were very low, which indicates that the melons were harvested while immature. There was a good correlation between taste and Brix value; the higher the Brix value, the better the taste (data not shown).

Table 8 shows results of external and internal quality.
Table 8  Summary of observations on rot development and Brix values. Percentage non-affected fruits (no rot) on days 6 and 8 and Brix value on day 12 of melons from different containers and of two layers (1 = bottom layer; 12 = upper layer). For Quest 2 container only the melons of similar grade in comparison to other treatments were scored.

<table>
<thead>
<tr>
<th>Container type</th>
<th>Layer</th>
<th>% non-affected day 6</th>
<th>% non-affected day 8</th>
<th>Brix value day 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
<td>Low</td>
<td>67</td>
<td>50</td>
<td>7.99</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>77</td>
<td>63</td>
<td>8.19</td>
</tr>
<tr>
<td>Quest 1</td>
<td>Low</td>
<td>93</td>
<td>67</td>
<td>8.19</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>73</td>
<td>53</td>
<td>8.20</td>
</tr>
<tr>
<td>Quest 2</td>
<td>Low</td>
<td>80</td>
<td>70</td>
<td>7.99</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>80</td>
<td>80</td>
<td>8.31</td>
</tr>
</tbody>
</table>

5.4  Average temperature and quality
No relation was found between average temperature and any quality indicator.
6 Conclusions

6.1 Power savings
The reference containers ref1 and ref2 used 10.5 and 6.6 kW. The Quest container had a mean power usage of 2.5 and 2.7 kW, mean savings are 68%. Although at the start of the trip dehumidification was set OFF, the melon reference containers have dehumidification energy readings. When accounting for the additional energy consumption due to the (erroneously activated) dehumidification, the reference containers had a mean power usage of 4.5 and 2.3 kW. Estimated savings are then 44% and -17% respectively.

6.2 Temperatures
The supply air of the Quest containers fluctuates in time, but with such a high frequency, that the fluctuations are hardly visible in the carton temperature data (measured with a 30 min period).

During Quest Regular Mode, the minimum supply temperature mostly does not reach supply setting, but stops at about 0.5°C above setpoint. Adaptation of the field software, after comparable issues for mandarin and apple, apparently did not help (enough) to prevent same for these melon shipments.

Overall, carton temperatures in the Quest container were satisfactory and reasonably close to the setpoint. The Quest container cartons were 0.3°C further from setpoint, while the bandwidth was 0.1°C smaller. The coolest cartons were just as close and the warmest cartons 0.1°C closer to the setpoint.

6.3 Product quality
Brix values were very low, which indicates that the melons were harvested while immature. No chilling injury indications were found.

Product quality was not affected by the container, pallet position or layer. Also, no relation was found between the average temperature and product quality. This indicates that the Quest regime did not change quality output compared to normal regime.
References

Appendix I: Ambient conditions between Brazil and Great Britain

Figure 16 Mean September temperature between Brazil and Great Britain [1]

Figure 17 Mean September relative humidity between Brazil and Great Britain [1]
### Table 10: Correctness of settings activation and deactivation of CPC and record of demultiplexing energy < 0.07. Test 2 and Test 2

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### Table 9: Correctness of settings activation and deactivation of CPC and record of demultiplexing energy < 0.07. Test 1 and Test 1

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### Appendix II: Settings and dehumanization during the trip
Appendix III: Carton temperatures

Figure 18 Temperature readings of Tiny Tags in cartons, all data, for both Melon 1 containers

Figure 19 Temperature readings of Tiny Tags in cartons, all data, for both Melon 2 containers
Figure 20  Temperature readings of Tiny Tags in cartons, coolest (-) and warmest (-) carton, as well as mean temperature for all cartons (-), for both Melon 1 containers.

Figure 21  Temperature readings of Tiny Tags in cartons, coolest (-) and warmest (-) carton, as well as mean temperature for all cartons (-), for both Melon 2 containers.
Appendix IV: Unit temperature readings as a function of time

Figure 22 Temperature readings from the unit for the Melon ref 1 container.
Figure 23 Temperature readings from the unit for the Melon test 1 container.
Figure 24 Temperature readings from the unit for the Melon ref 2 container.
Figure 25 Temperature readings from the unit for the Melon test 2 container.
Appendix V: Snapshot pictures of carton temperature readings

Figure 26   Tiny Tag readings of the carton temperatures on Sept. 20th '06 00:00, 5 days after the start of the trip, Melon 1.
Figure 27 Tiny Tag readings of the carton temperatures on Sept. 20th '06 00:00, 5 days after the start of the trip, Melon 2.
time = 288.0 h

reference container

Quest Regular container

Figure 28  Tiny Tag readings of the carton temperatures near the end of the trip, on Sept. 27th '06 00:00, Melon 1
Figure 29  Tiny Tag readings of the carton temperatures near the end of the trip, on Sept. 27th '06 00:00, Melon 2
Appendix VI: Ambient temperatures

Figure 30  Ambient temperature readings from the Tiny Tag/Ibutton on the outside of the Quest regular test container, Melon test 1.

Figure 31  Ambient temperature readings from the Tiny Tag/Ibutton on the outside of the container, Melon test 2 and ref 2.
Appendix VII: Unit activity graphs

Figure 32. The number of minutes per cooling, non-cooling and defrost period as a function of time for the Quest Melon containers. At each time instant during the voyage when a period is finished a bar is drawn with the number of minutes that that period has lasted. If the period is smaller than an hour, the bars turn into a line.
Figure 33 The number of minutes active, non-active and defrost period as a function of time for the Melon 1 containers. Every hour of the trip the number of minutes that was used for defrost was recorded. The number of minutes the unit was active was recorded as well, which is mostly 60 min/hour but sometimes less.
Figure 34 The number of minutes active, non-active and defrost period as a function of time for the Melon 2 containers. Every hour of the trip the number of minutes that was used for defrost was recorded. The number of minutes the unit was active was recorded as well, which is mostly 60 min/hour but sometimes less.