AGROTECHNOLOGY & FOOD SCIENCES GROUP
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Fifth Quest Regular Trial Shipment

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

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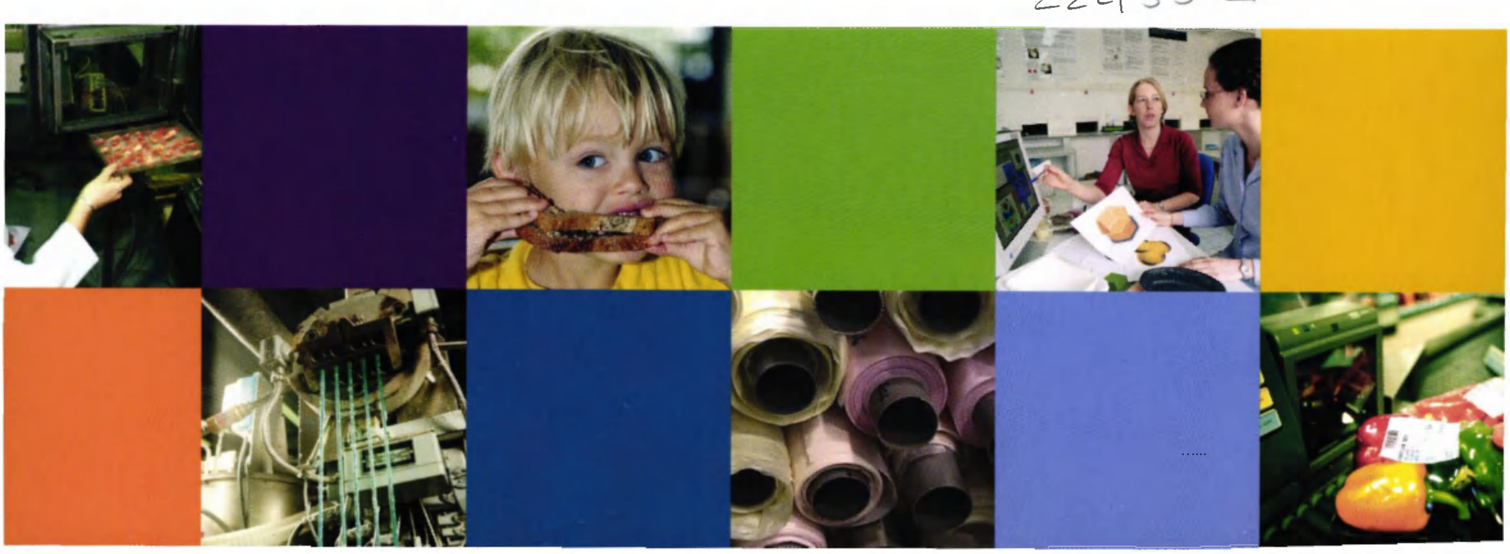
Report 736



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Title	Fifth Quest Regular Trial Shipment
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AFSG number	736
ISBN-number	-
Date of publication	January 24th 2007
Confidentiality	Yes
OPD code	-
Approved by	H.Maas

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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.

Quality inspections at arrival and power and temperature data logging were supported by Smitmar and MMS. We would like to thank Mr. Smit, Mr. Bishop and Mr. Pailes for sharing their data files and findings with us, part of which were used for this report.

We are indebted to our A&F colleagues Mr. van den Boogaard, Mr. Boerrigter, Mr. Woltering and Mrs. Otma for their help during the organisation of the trial and its preparations as well as the product quality assessments.

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

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 trail 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.

Figure 1 Galia Melon

Figure 2 Galia Melon open

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 2 Container setup

Container nr	Setup mode	Stuffing date	Commodity	Grower
PONU 475 491 4	NORMAL (ref2)	14/9/2006	Melon	J.S. Sallouti
MWCU 675 250 4	CCPC (test1)	12/9/2006	Melon	J.S. Sallouti
PONU 475 698 5	CCPC (test2)	14/9/2006	Melon	J.S. Sallouti
MWCU 681 026 2	NORMAL (ref1)	13/7/2006	Melon	J.S. Sallouti

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

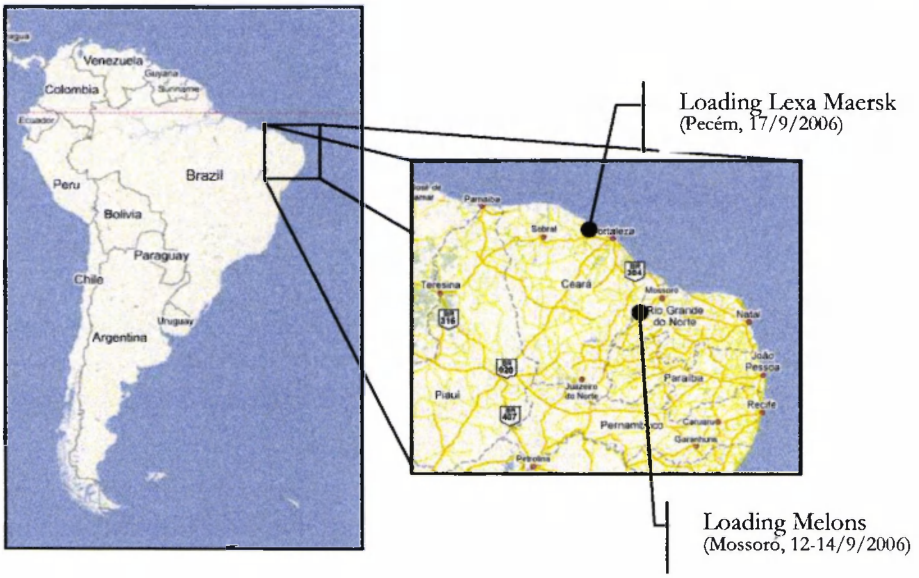

Figure 3 Map of loading and departure locations

Figure 4 Map of the vessel route

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.

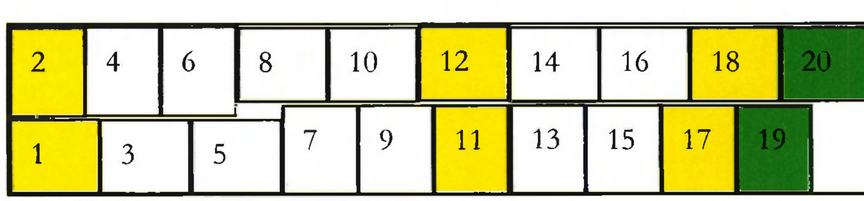

Figure 5 Container layout

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. 15th 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.

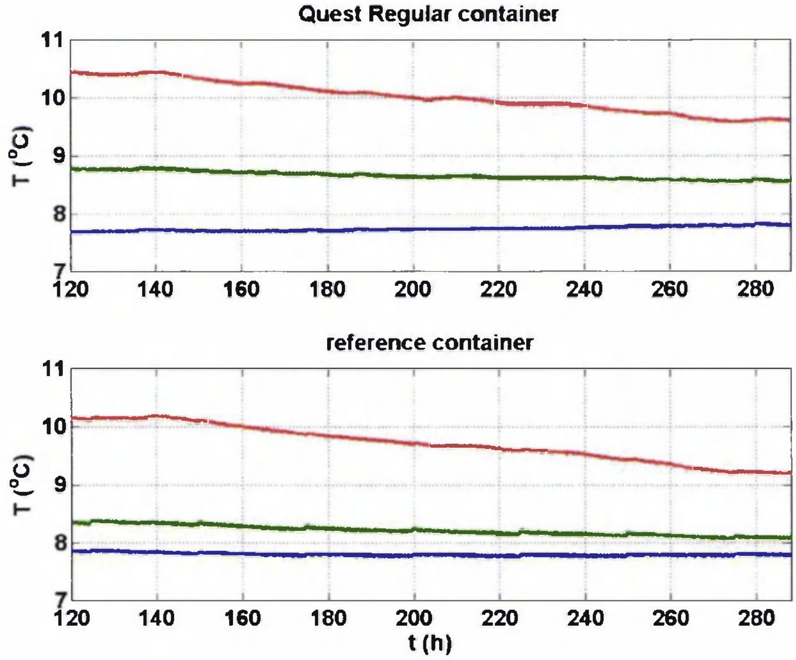

Figure 6 Temperature readings of Tiny Tags in cartons, coolest (-) and warmest (-) carton, as well as mean temperature for all cartons (-), for both Melon 1 containers

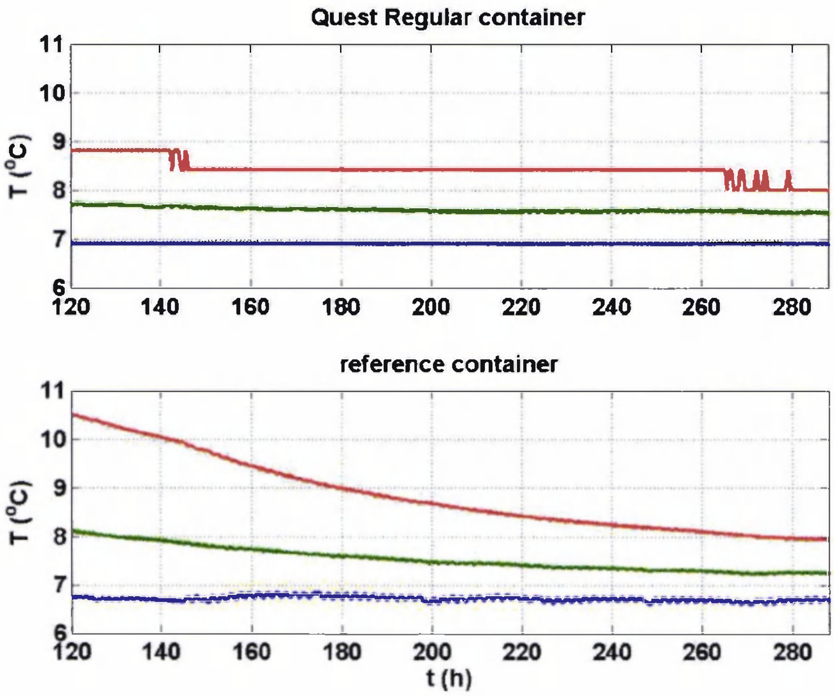

Figure 7 Temperature readings of Tiny Tags in cartons, coolest (-) and warmest (-) carton, as well as mean temperature for all cartons (-), for both Melon 2 containers

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. 20[th] until Sept. 27[th], 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 0 and 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 then 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 then 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)

	min carton T (°C)	mean carton T (°C)	max carton T (°C)
Quest container 1	7.7 to 7.8	8.5 to 8.8	9.6 to 10.4
Quest container 2	6.9 to 6.9	7.5 to 7.7	8.0 to 8.8
reference cont. 1	7.7 to 7.9	8.1 to 8.4	9.2 to 10.2
reference cont. 2	6.6 to 6.8	7.2 to 8.1	7.9 to 10.5

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

	mean min carton T (°C)	mean mean carton T (°C)	mean max carton T (°C)
Quest container 1	7.7	8.6	10.0
Quest container 2	6.9	7.6	8.4
reference cont. 1	7.8	8.2	9.7
reference cont. 2	6.7	7.5	8.8

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

	dev min carton T (°C)	dev mean carton T (°C)	dev max carton T (°C)
Quest container 1	0.5 to 0.6	1.3 to 1.6	4.4 to 3.2
Quest container 2	-0.3 to -0.3	0.3 to 0.5	0.8 to 1.6
reference cont. 1	0.5 to 0.7	0.9 to 1.2	2.0 to 3.0
reference cont. 2	-0.6 to -0.4	0.0 to 0.9	0.7 to 3.3

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

	dev mean min carton T (°C)	dev mean mean carton T (°C)	dev mean max carton T (°C)
Quest container 1	0.5	1.4	2.8
Quest container 2	-0.3	0.4	1.2
reference cont. 1	0.6	1.0	2.5
reference cont. 2	-0.5	0.3	1.6

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

	ΔT coolest carton (°C)	ΔT mean carton (°C)	ΔT warmest carton (°C)
|ref 1| - |Quest 1|	+0.1	-0.4	-0.3
|ref 2| – |Quest 2|	+0.2	-0.1	+0.4

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.

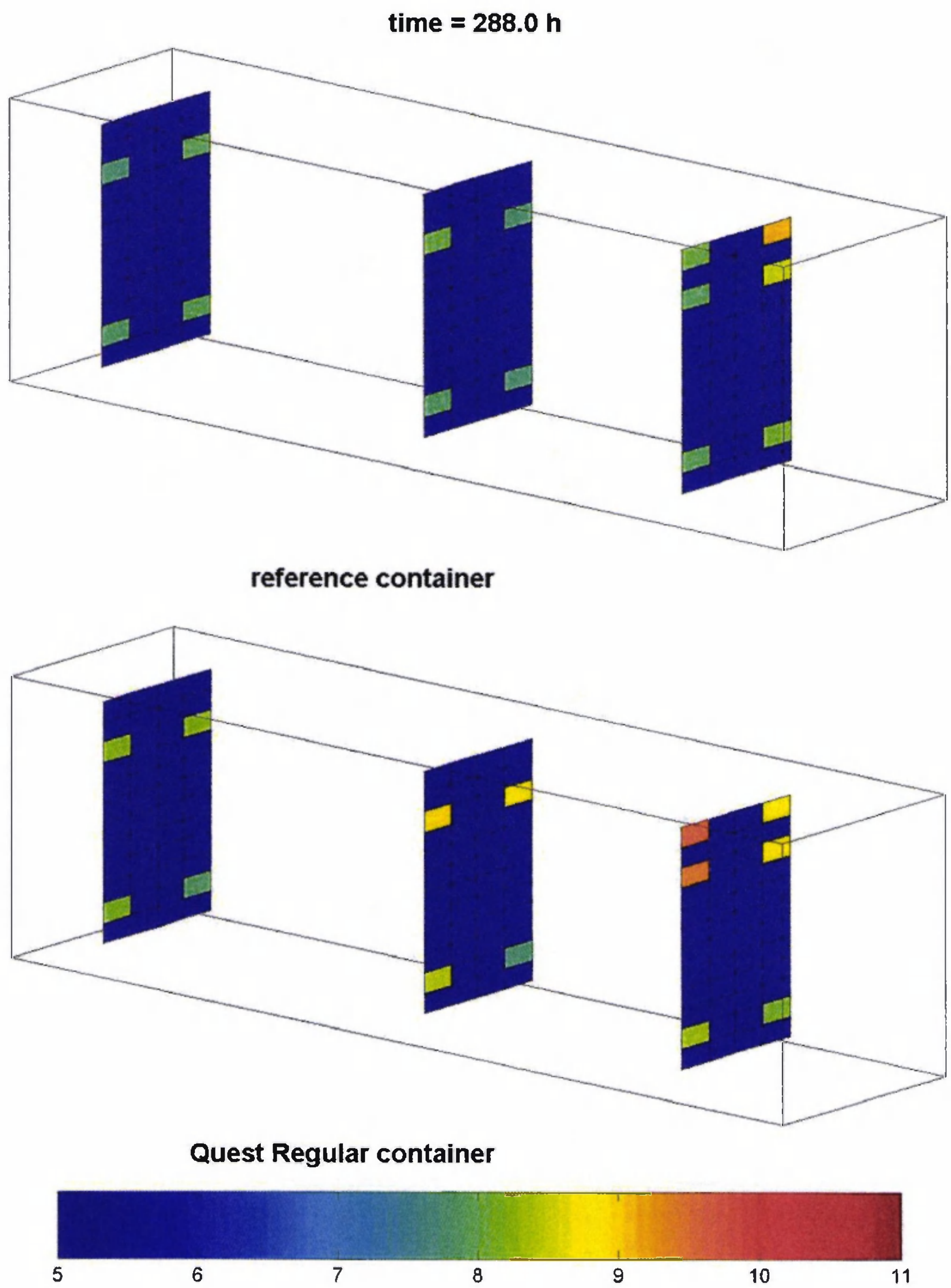

Figure 8 Tiny Tag readings of the carton temperatures near the end of the trip, on Sept. 27th '06 00:00, Melon 1.

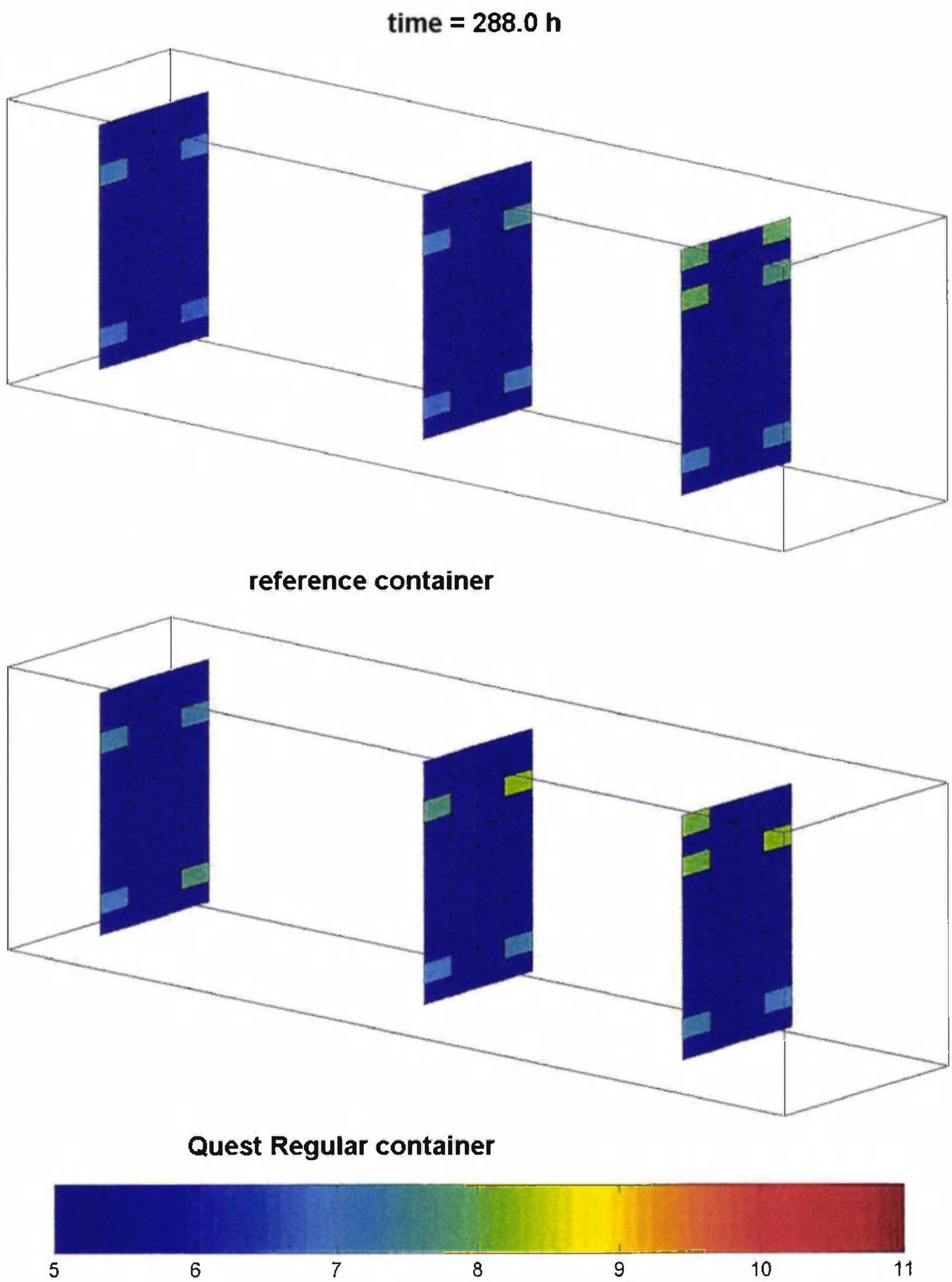

Figure 9 Tiny Tag readings of the carton temperatures near the end of the trip, on Sept. 27th '06 00:00, Melon 2.

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.

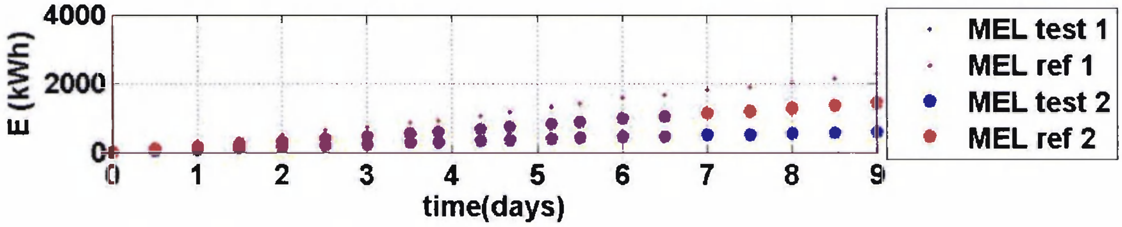

Figure 10 Energy readings as a function of time for both container sets

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 1/3rd).

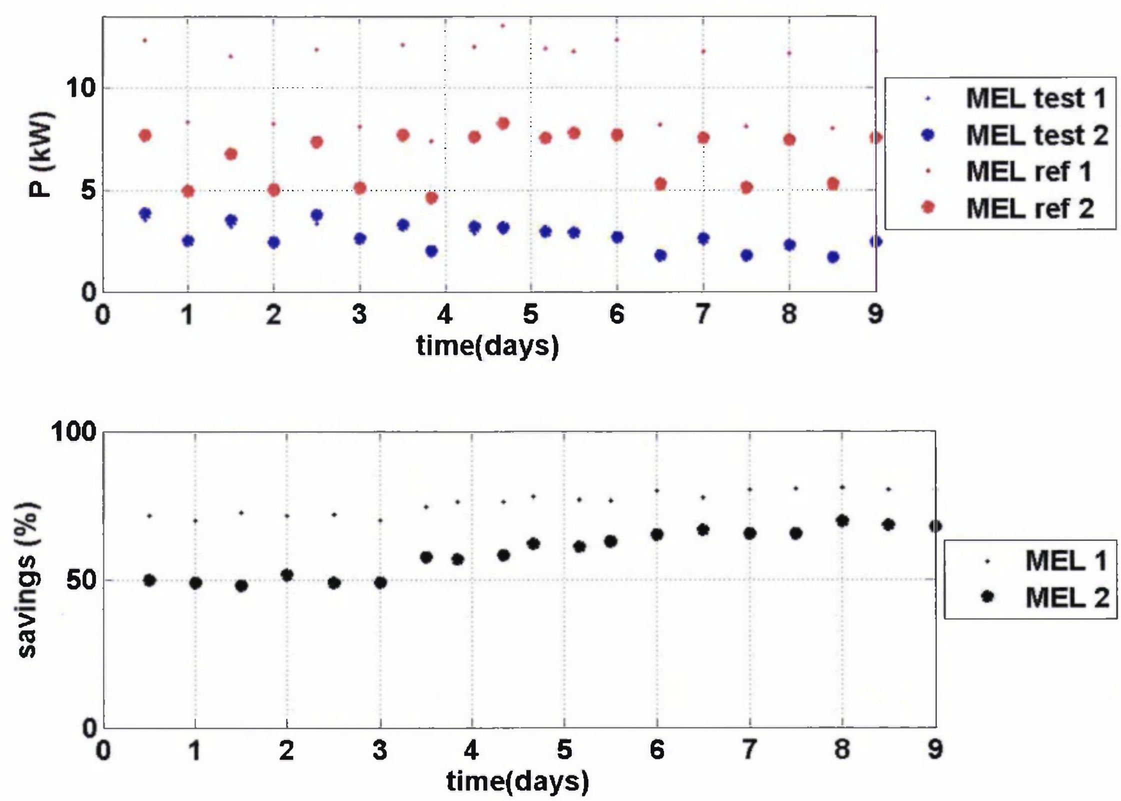

Figure 11 Power and savings as a function of time for both container sets

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

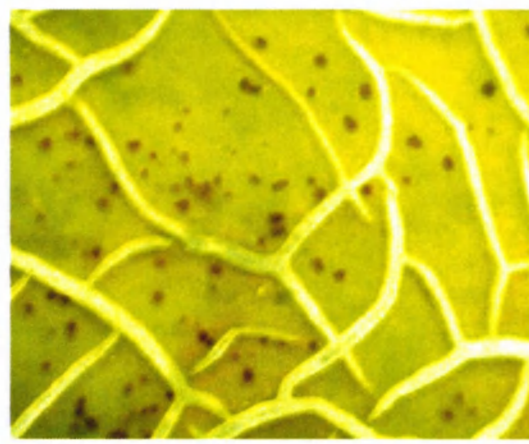

Figure 13 Small brown spots

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

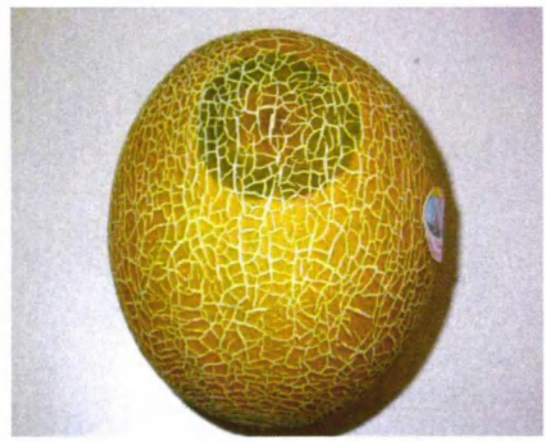

Figure 15 Severe Rot

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.

Container type	Layer	% non-affected day 6	% non-affected day 8	Brix value day 10
Reference	Low	67	50	7.99
	High	77	63	8.19
Quest 1	Low	93	67	8.19
	High	73	53	8.20
Quest 2	Low	80	70	7.99
	High	80	80	8.31

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

[1] http://www.cdc.noaa.gov/cgi-bin/Composites/comp.pl

Appendix I: Ambient conditions between Brazil and Great Britain

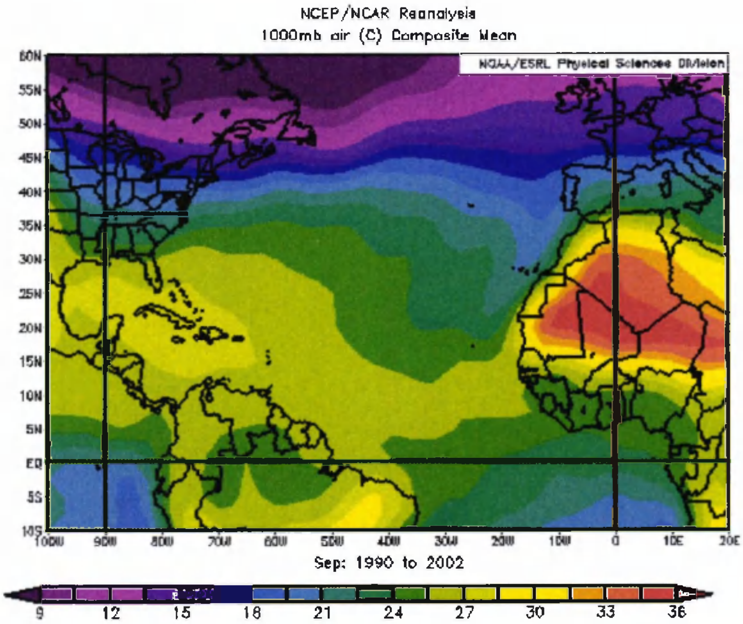

Figure 16 Mean September temperature between Brazil and Great Britain [1]

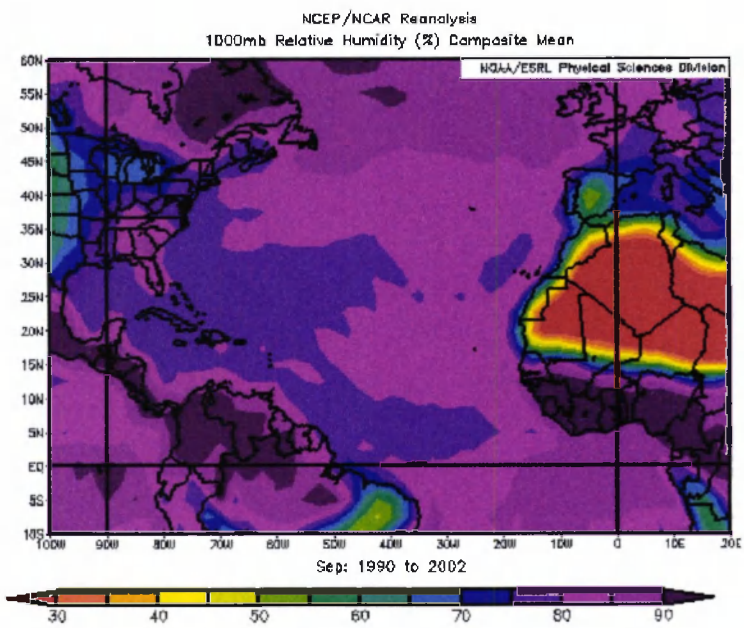

Figure 17 Mean September relative humidity between Brazil and Great Britain [1]

Appendix II: Settings and dehumidification during the trip

Table 9 Correctness of settings, activation and deactivation of CCPC and record of dehumidification energy > 0, ref 1 and test 1

date	time	ref 1, settings (no AL)	ref 1, dehum (3.6 kW)	test 1, settings (AL 64)	test 1, dehum (0 kW)
13-sep	**morning**	set OK	-	NORMAL, set OK	-
16-sep	**evening**	set OK	NO, OK	CCPC act, set OK	NO, OK
17-sep	**morning**	set OK	DEHUM	set OK	NO, OK
17-sep	**evening**	set OK, departure	DEHUM	set OK	NO, OK
27-sep	**morning**	set OK, arrival	DEHUM	set OK, arrival	NO, OK
28-sep	**morning**	set OK, stripped	DEHUM	set OK, stripped	NO, OK

Table 10 Correctness of settings, activation and deactivation of CCPC and record of dehumidification energy > 0, ref 2 and test 2

date	time	ref 2, settings (no AL)	ref 2, dehum (2.6 kW)	test 2, settings (AL64)	test 2, dehum (0 kW)
13-sep	**evening**	-	-	NORMAL, set 5.0	-
14-sep	**morning**	set SP = 5.6	-	NORMAL, set 5.0	-
15-sep	**morning**	set SP = 7.5	-	NORMAL, set 5.0	-
16-sep	**evening**	set OK	NO, OK	CCPC act, set OK	NO, OK
17-sep	**morning**	set OK	DEHUM	set OK	NO, OK
17-sep	**evening**	set OK, departure	DEHUM	set OK	NO, OK
27-sep	**morning**	set OK	DEHUM	set OK, arrival	NO, OK
28-sep	**morning**	set OK, arrival	DEHUM	set OK, stripped	NO, OK
29-sep	**evening**	set OK, stripped	DEHUM	-	-

Appendix III: Carton temperatures

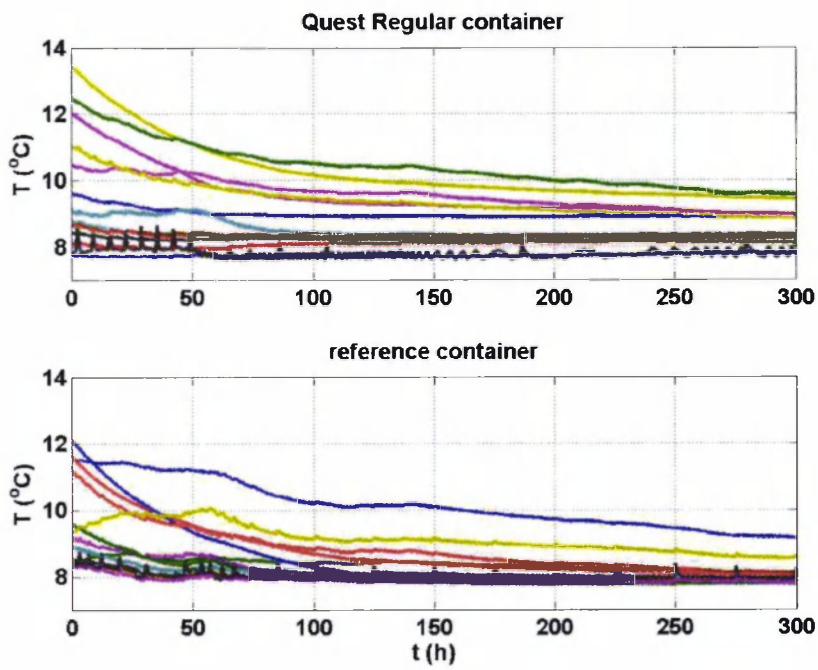

Figure 18 Temperature readings of Tiny Tags in cartons, all data, for both Melon 1 containers

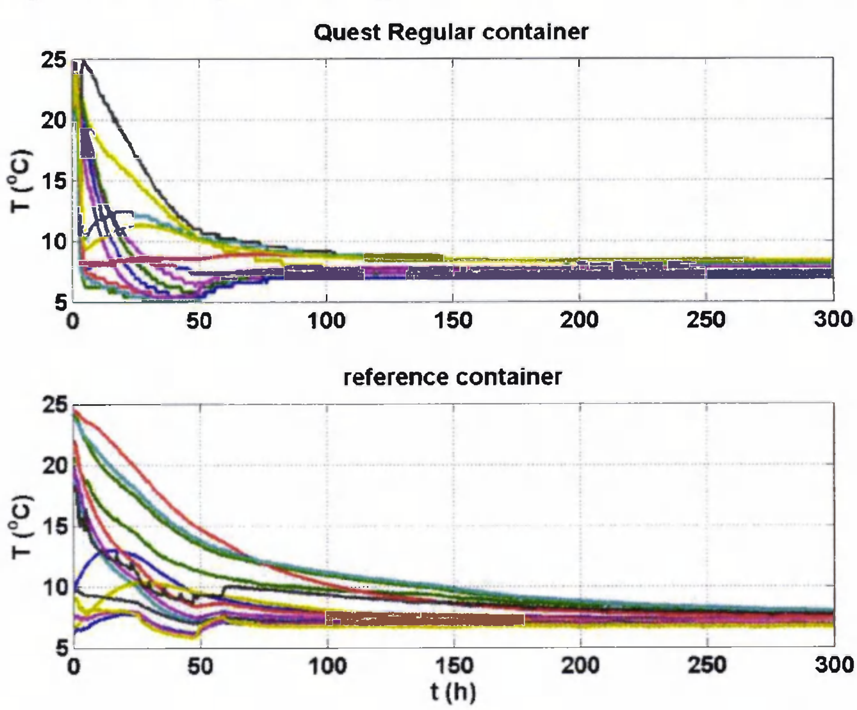

Figure 19 Temperature readings of Tiny Tags in cartons, all data, for both Melon 2 containers

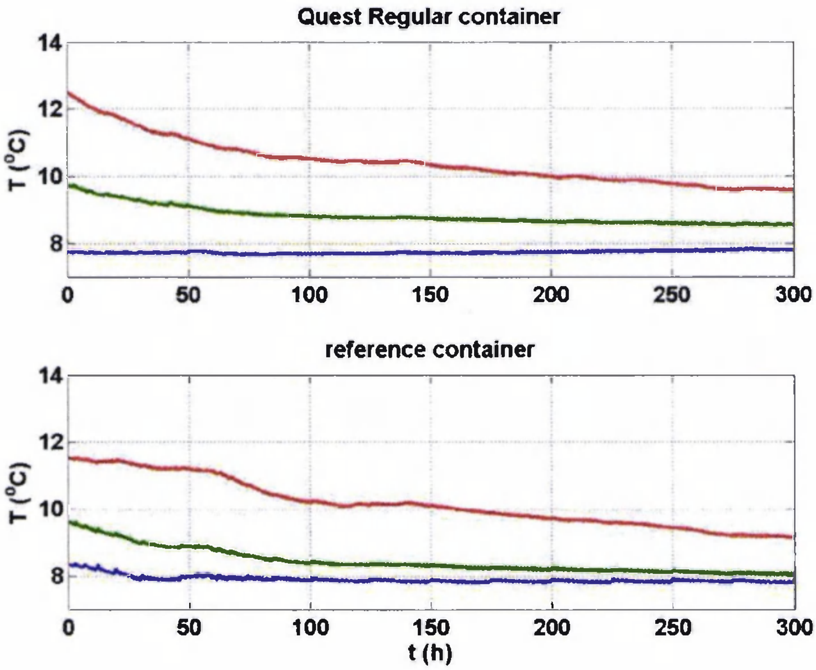

Figure 20 Temperature readings of Tiny Tags in cartons, coolest (-) and warmest (-) carton, as well as mean temperature for all cartons (-) , for both Melon 1 containers

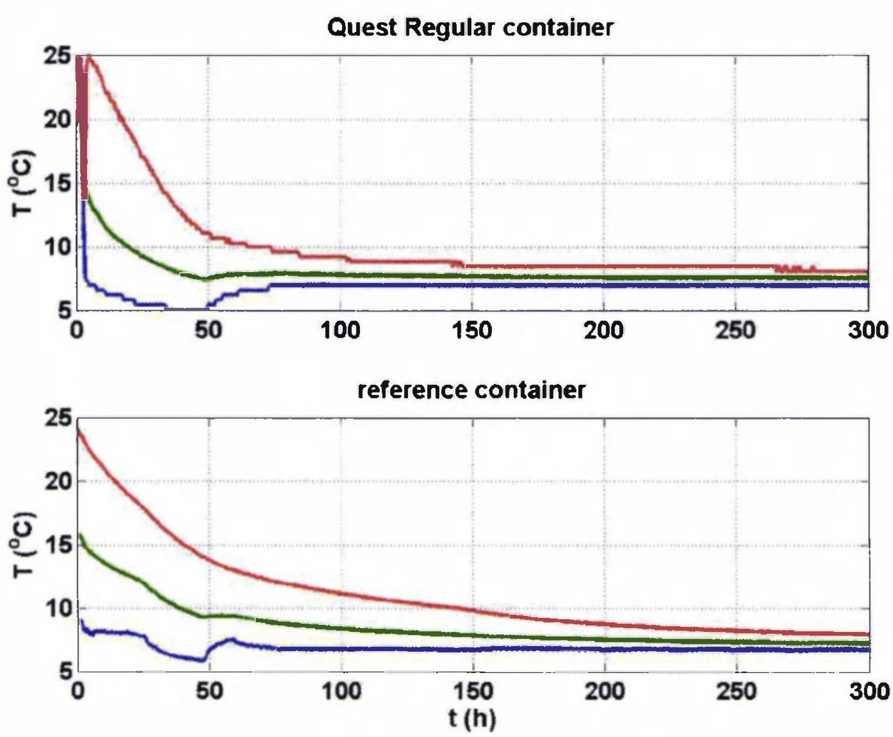

Figure 21 Temperature readings of Tiny Tags in cartons, coolest (-) and warmest (-) carton, as well as mean temperature for all cartons (-) , for both Melon 2 containers

Appendix IV: Unit temperature readings as a function of time

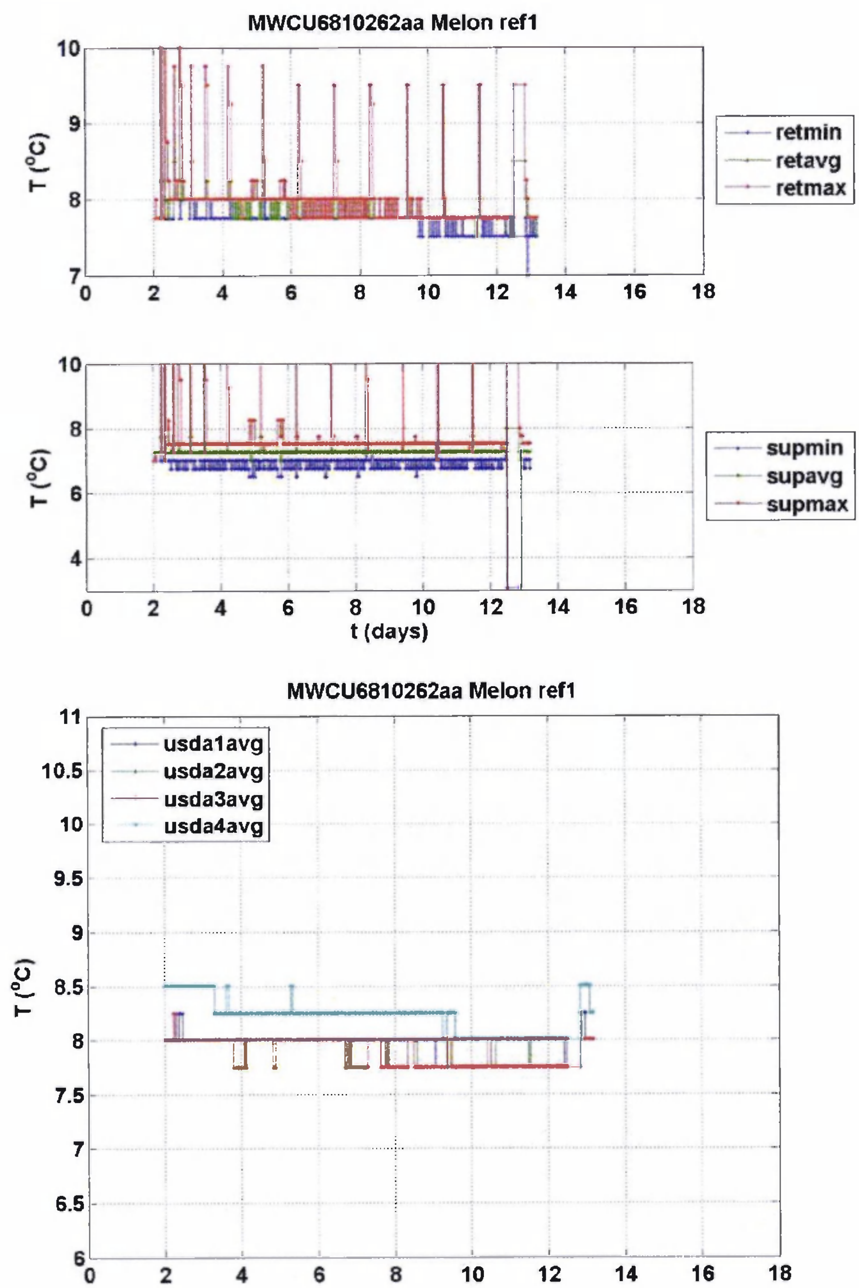

Figure 22 Temperature readings from the unit for the Melon ref 1container.

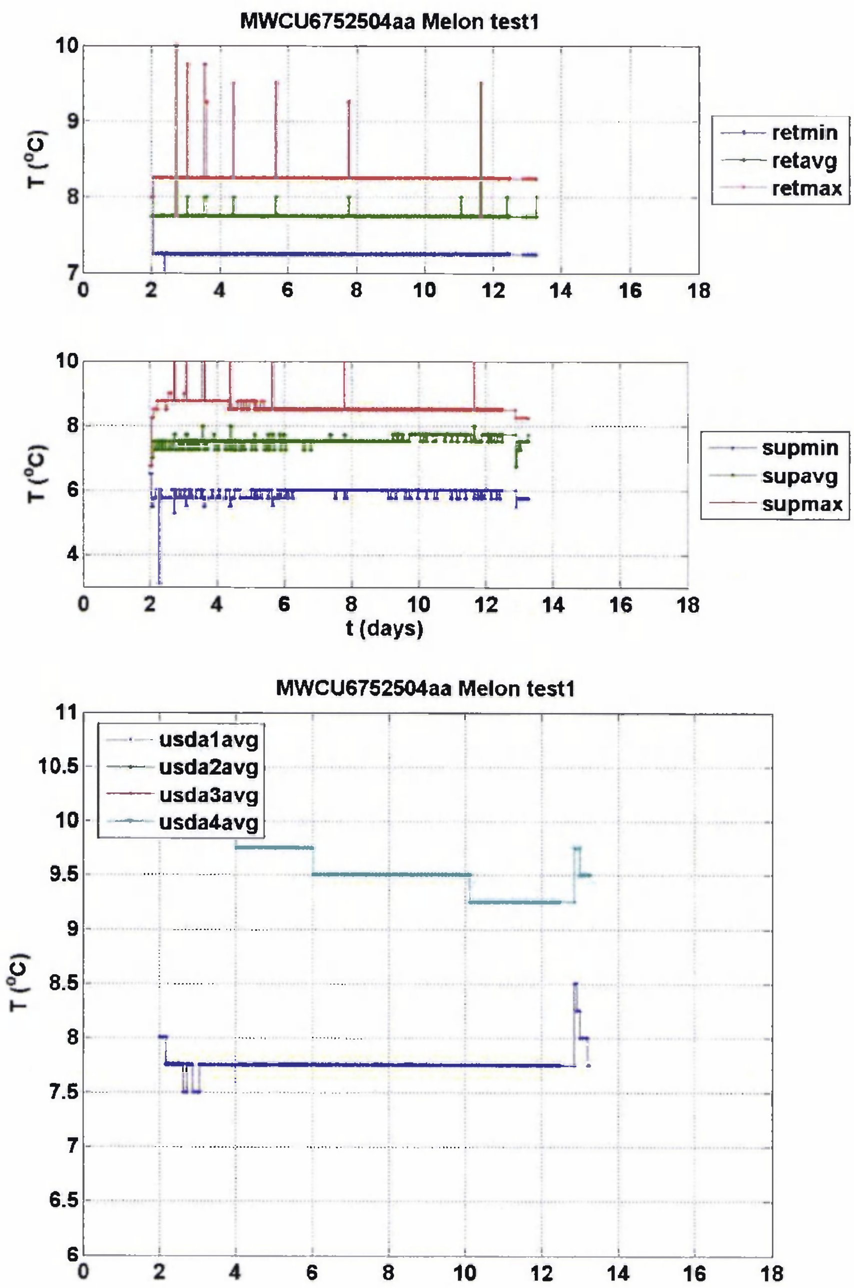

Figure 23 Temperature readings from the unit for the Melon test 1container.

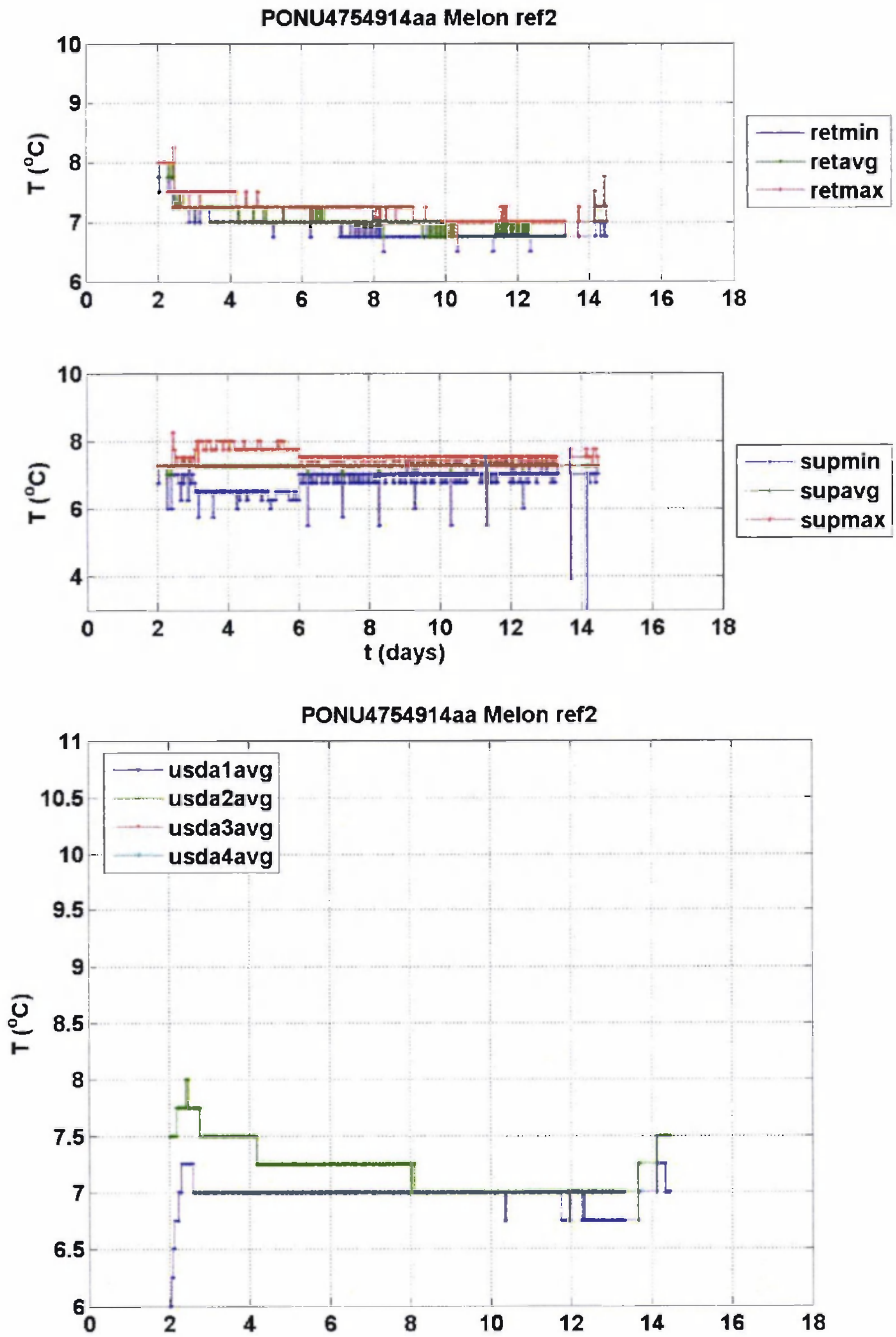

Figure 24 Temperature readings from the unit for the Melon ref 2 container.

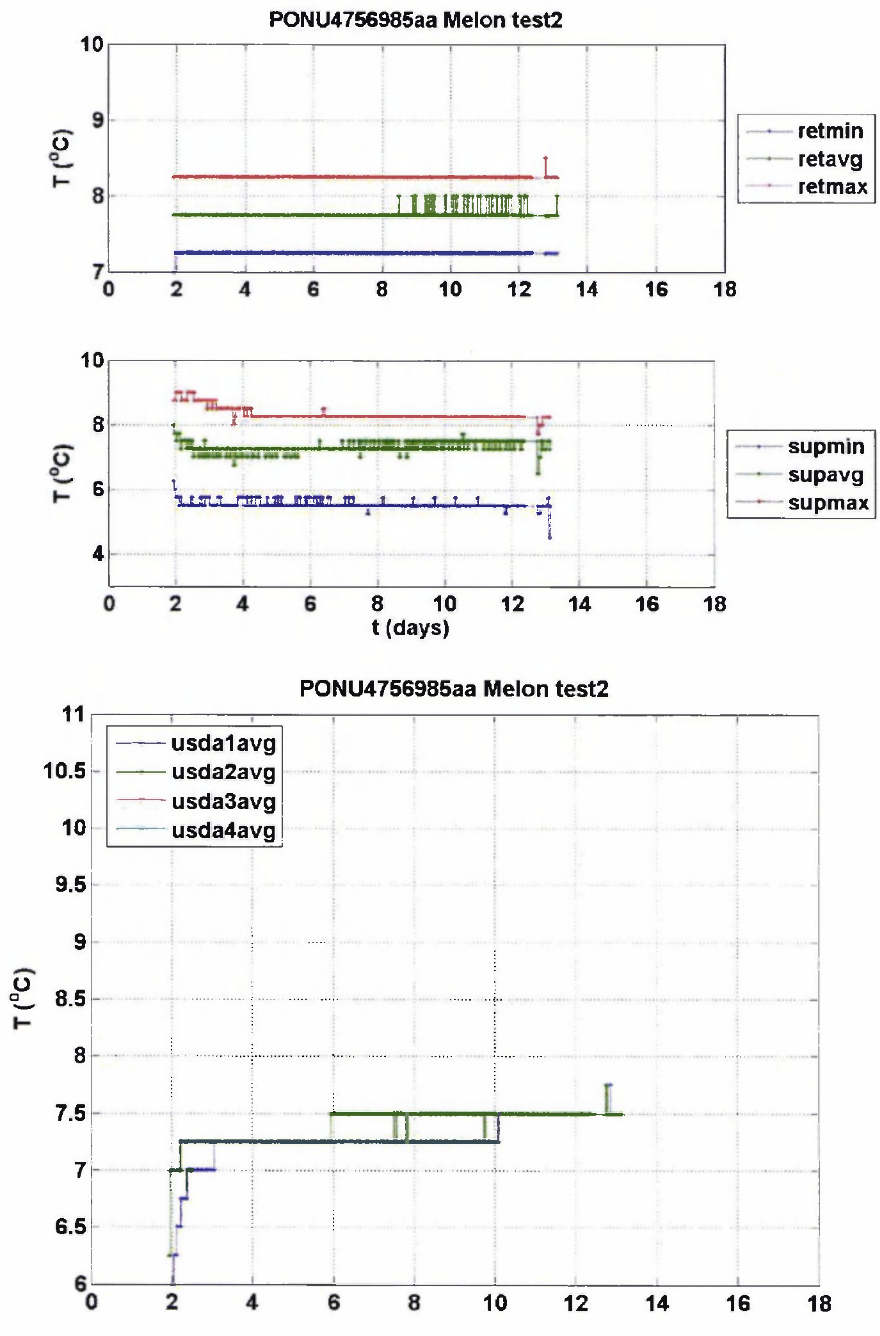

Figure 25 Temperature readings from the unit for the Melon test 2 container.

Appendix V: Snapshot pictures of carton temperature readings

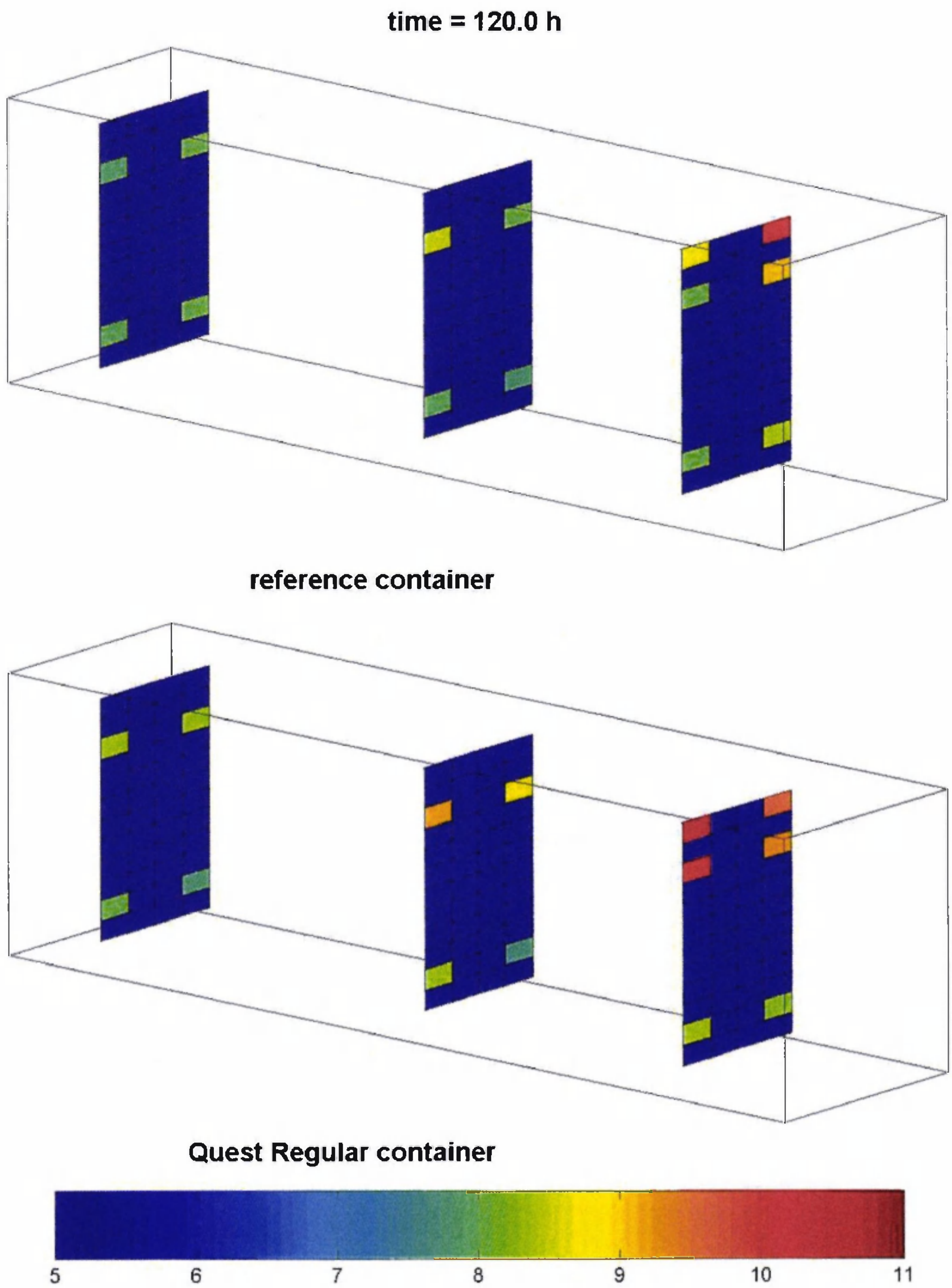

Figure 26 Tiny Tag readings of the carton temperatures on Sept. 20th '06 00:00, 5 days after the start of the trip, Melon 1.

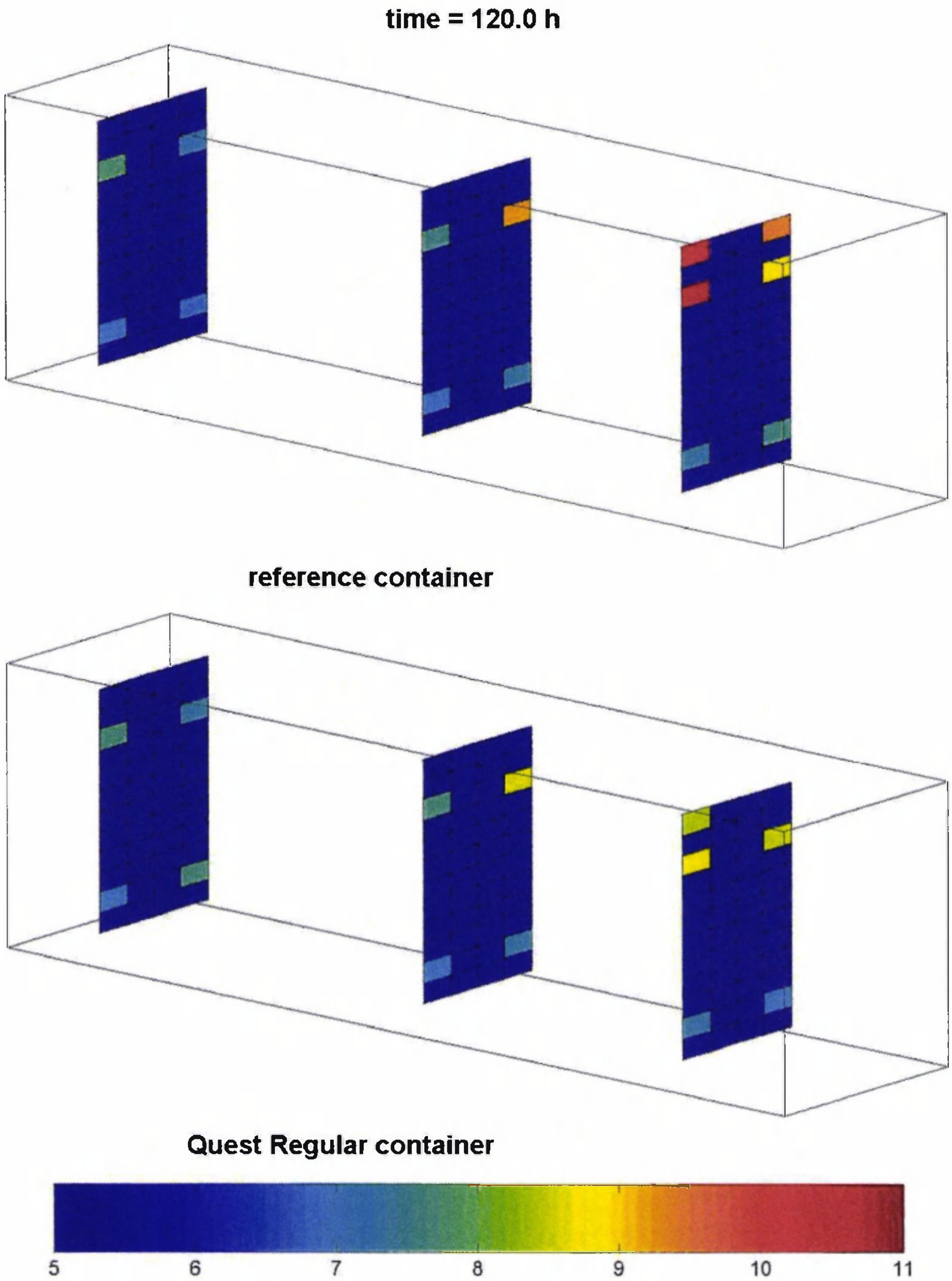

Figure 27 Tiny Tag readings of the carton temperatures on Sept. 20th '06 00:00, 5 days after the start of the trip, Melon 2.

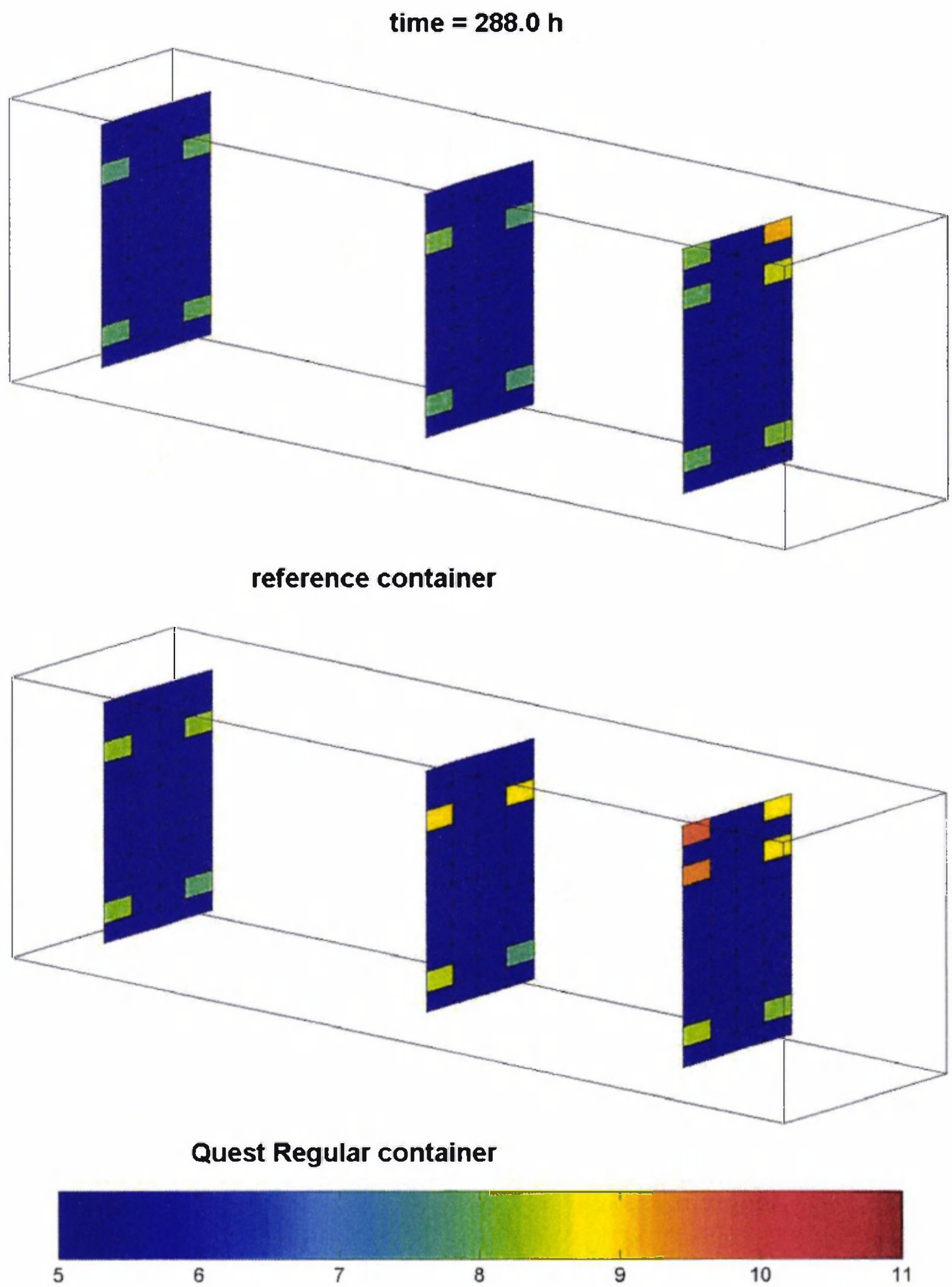

Figure 28 Tiny Tag readings of the carton temperatures near the end of the trip, on Sept. 27th '06 00:00, Melon 1

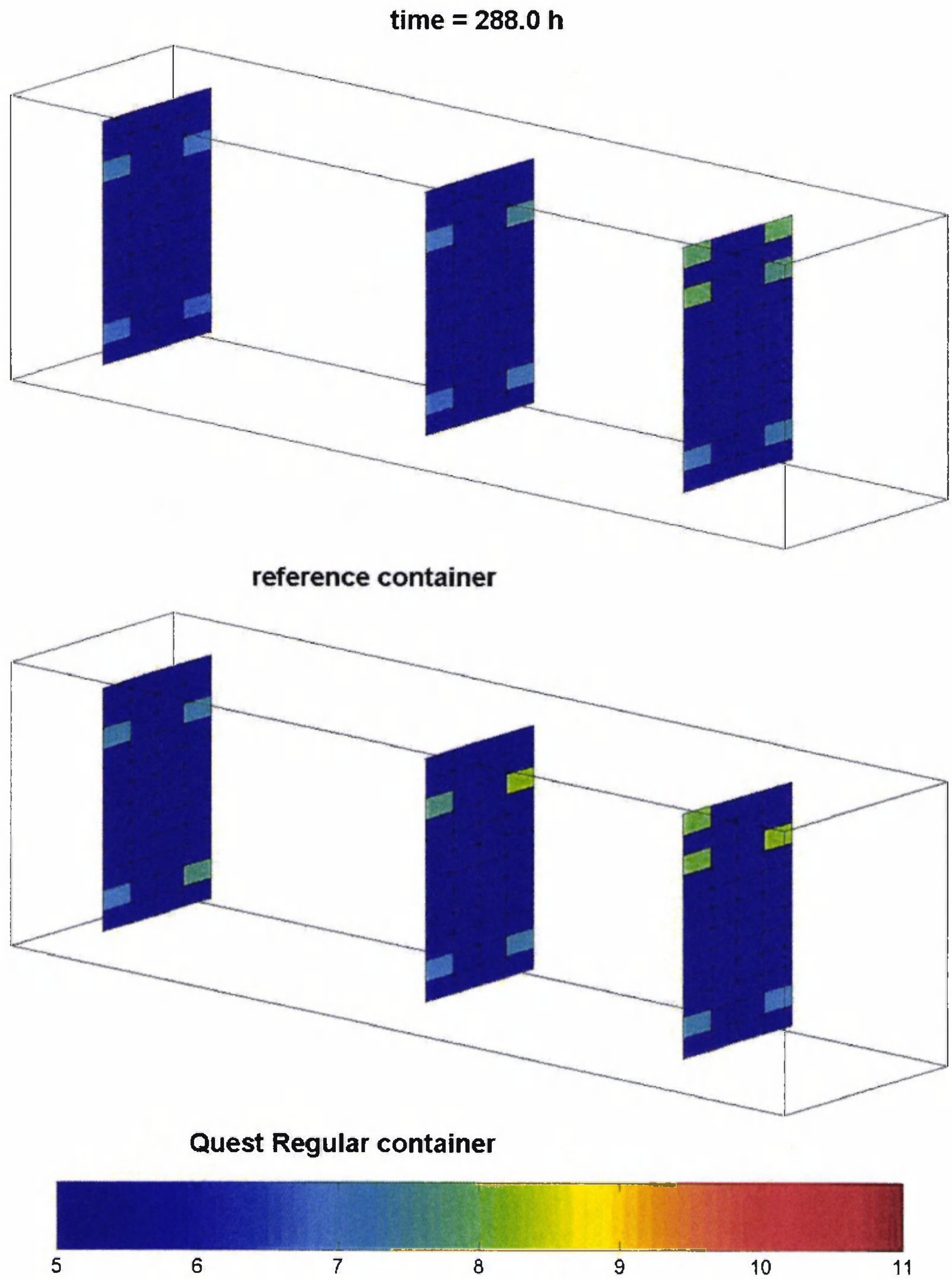

Figure 29 Tiny Tag readings of the carton temperatures near the end of the trip, on Sept. 27th '06 00:00, Melon 2

Appendix VI: Ambient temperatures

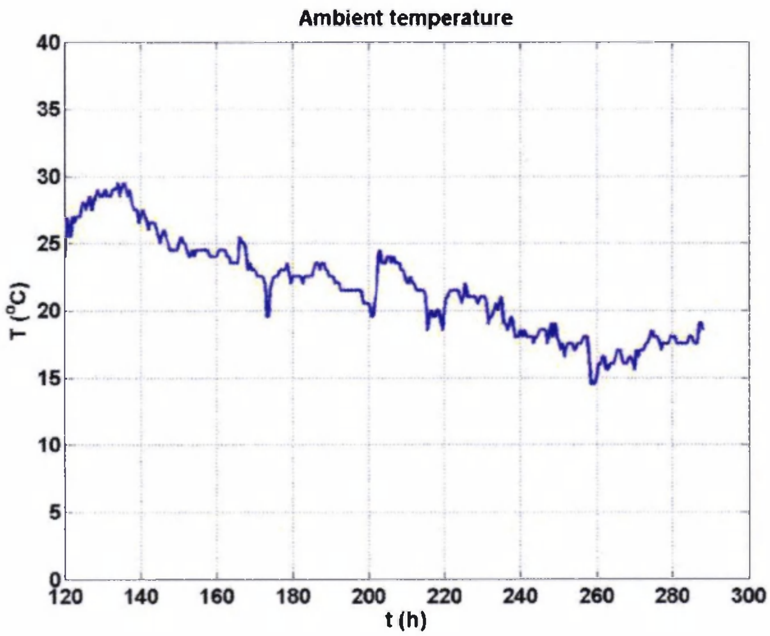

Figure 30 Ambient temperature readings from the Tiny Tag/Ibutton on the outside of the Quest regular test container, Melon test 1.

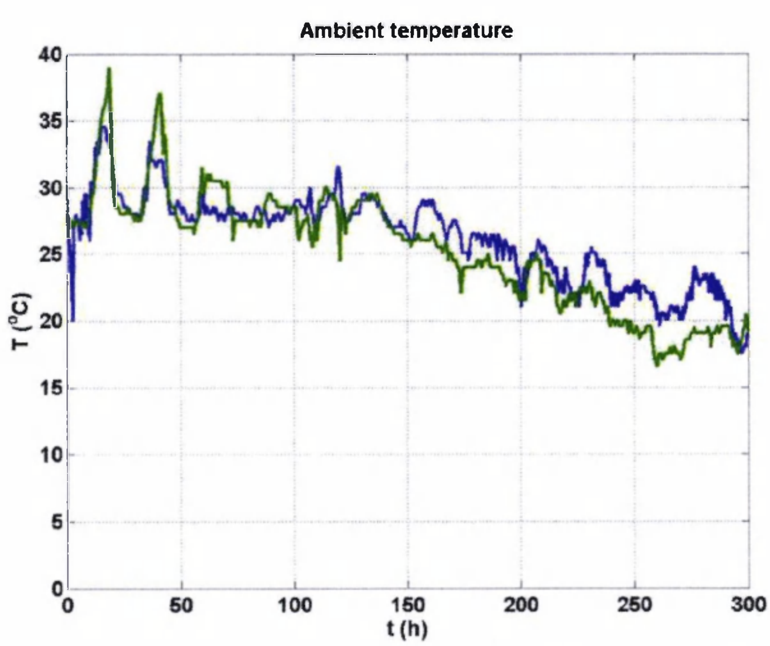

Figure 31 Ambient temperature readings from the Tiny Tag/Ibutton on the outside of the container, Melon test 2 and ref 2.

Appendix VII: Unit activity graphs

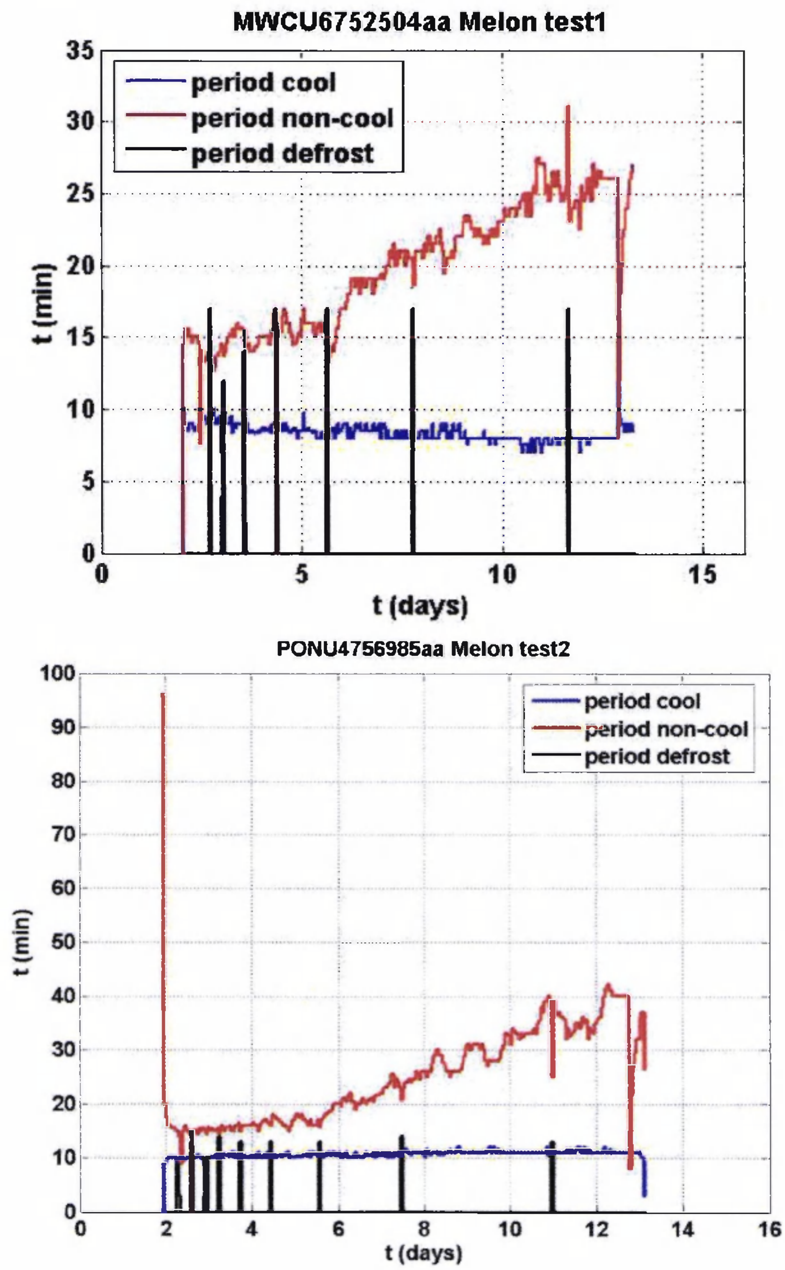

Figure 32 The number of minutes per cooling, non-cooling and defrost period as a function of time for the Quest Melon containers. At each time instant during the voyage when a period is finished a bar is drawn with the number of minutes that that period has lasted. If the period is smaller than an hour, the bars turn into a line.

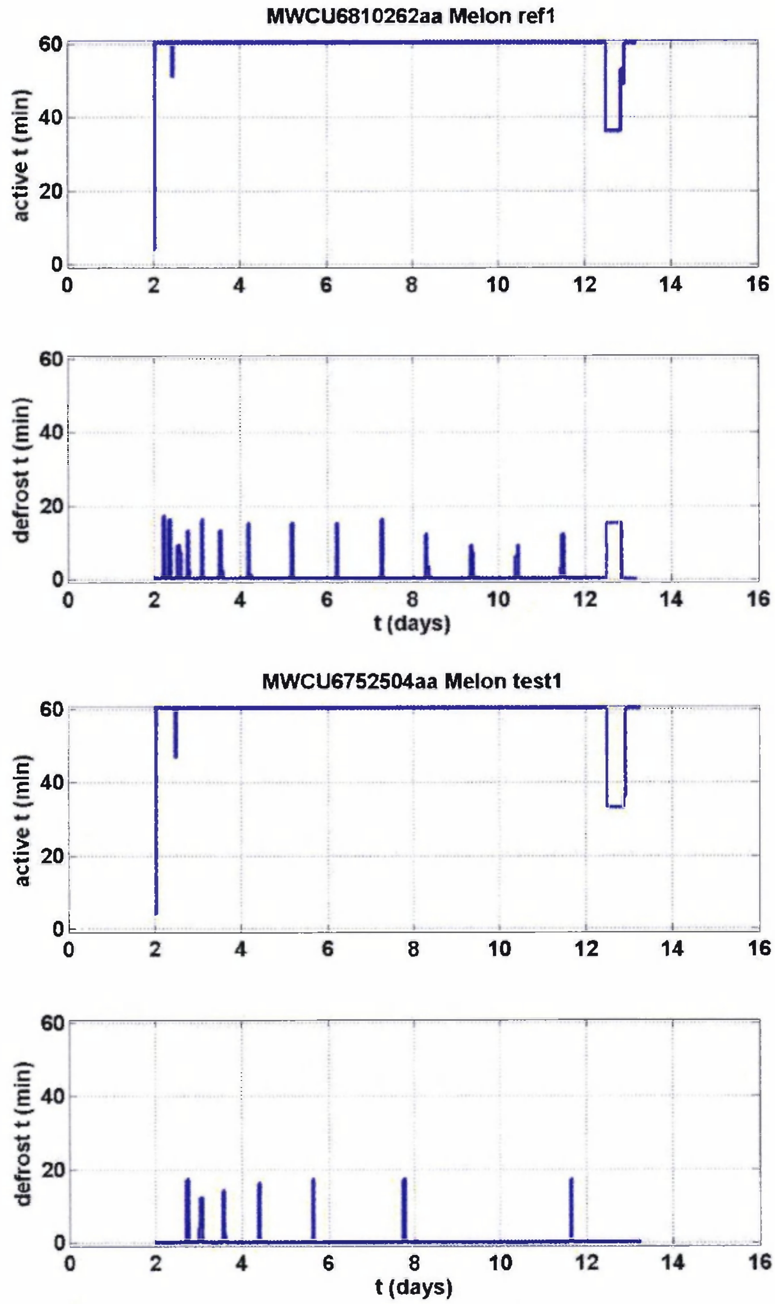

Figure 33 The number of minutes active, non-active and defrost period as a function of time for the Melon 1 containers. Every hour of the trip the number of minutes that was used for defrost was recorded. The number of minutes the unit was active was recorded as well, which is mostly 60 min/hour but sometimes less.

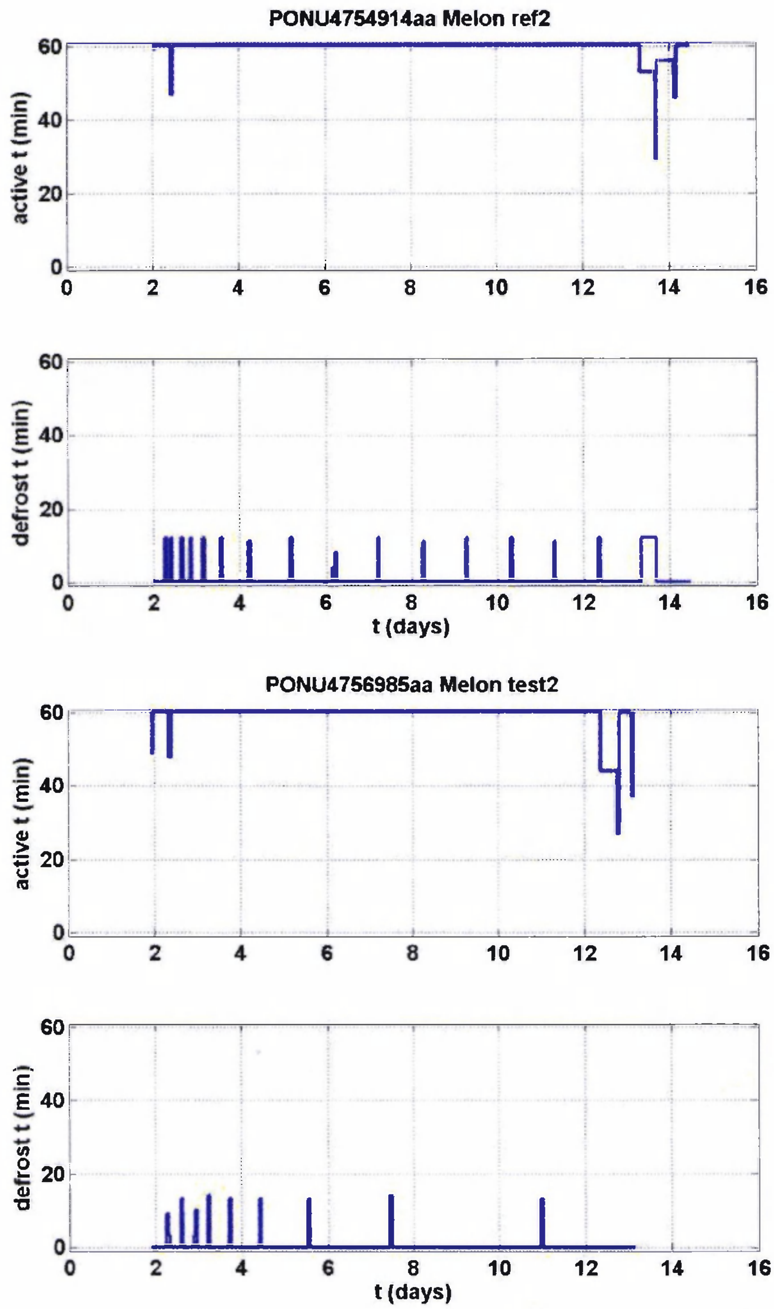

Figure 34 The number of minutes active, non-active and defrost period as a function of time for the Melon 2 containers. Every hour of the trip the number of minutes that was used for defrost was recorded. The number of minutes the unit was active was recorded as well, which is mostly 60 min/hour but sometimes less.