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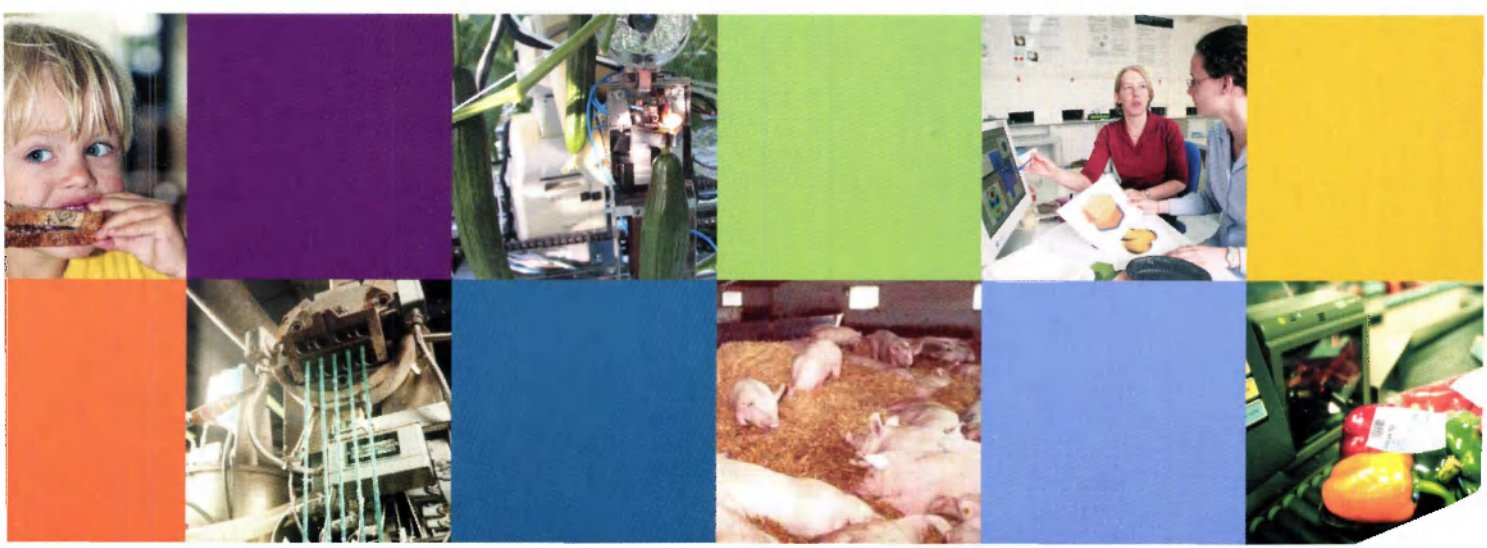
Report 245



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Content

1 Introduction

1.1 Project humidity control in reefer containers

Carrier Transicold produces and develops equipment for controlling the climate and power generation in reefer containers. This type of container is used for transportation of fresh horticultural produce. Temperature, humidity, oxygen and carbon dioxide conditions all influence the maintenance of product quality. In practice, however, most of the time only temperature is regulated. The benefits of humidity control are not always clear. Carrier Transicold feels the need for more insight into the benefits of humidity control. In addition, requirements are needed for a container with an effective and inherently safe humidity control system. In the humidity control project these issues will be investigated in four subtasks, namely: chain inventory, microbial contamination and health risks, product quality effects and climate model studies. This report describes the results of the chain inventory.

1.2 Chain inventory

This report is the outcome of an inventory that has been executed in the distribution chain of fruits and vegetables in The Netherlands, Belgium and South Africa. With the Netherlands and South Africa included a large volume of relevant product streams is covered.
Aim of this chain inventory was to list humidity control related problems and requirements of the practical players of distribution chains of fresh fruits and vegetables (with somewhere in the chain transportation with reefer containers). For this reason ATO has tried to avoid influencing the interviewed persons with ATO knowledge. For ATO most answers were affirmative. Therefore, this report does not describe new knowledge, but does give an overview of the issues that are important to the various chain partners.

2 Materials & methods

The chain inventory was made through interviews with the following persons:

1. FTK Holland B.V. (importer/exporter (sub)tropical fruits), Arie den Uyl (manager of the warehouse)
2. Harmsen & De Groot (Survey Bureau fruits and vegetables), Otto de Groot (Surveyor)
3. Special Fruit N.V. (importer/exporter fruit), Patrick Maes (manager, director)
4. Coolcontrol (terminal, storage and distribution tropical fruits imported through reefer containers, Reinier Stijnen (quality control).
5. Kappa Packaging (Companies in the production, development and sale of containerboard, solid board, corrugated and solid board packaging, graphic and specialty board), Mees Rouwkema (researcher packaging development)
6. Capespan (exporter/importer of fresh fruit internationally), Martin Taylor (Research Manager Post harvest)
7. ATO contacted the persons that they wanted to interview by telephone. Prior to the interview an e-mail was sent to the persons that were going to be interviewed. The contents of the e-mail were a confirmation of the appointment and a written explanation about the subject and aim of the interview in order to prepare the interview.

During the interviews the following items were discussed:

<u>General</u>

- What damage on fruits and vegetables is observed that is related to humidity control in containers and to what extend (how often does this kind of damage show)
- Does damage occur because of too much moisture present or because of too much moisture loss

<u>Product related items</u>

- Which fruit and vegetable products are very sensitive for fungus development
- What are the most important pathogens
- To what extent is the humidity control in a container responsible for such quality problems
- What are solutions

<u>Package related items</u>

- What damage is observed in containers on packaging
- To what extend is the damage on the packages due to moisture (control)
- What are other causes for damage on packaging and to what extend
- To what extend is the construction of the box responsible for the damage and to what extend is the package material responsible

Container improvements

- General discussion on control of container climate (temperature and humidity)
- General discussion on suggestions for improvement of the quality of the fruits and vegetables at arrival related to container control, stowage, knowledge etc.

3 Results

3.1 Damage on fruits and vegetables related to moisture loss

Dehydration of fruits and vegetables has an effect on quality. Above 4-5% water loss products start shriveling or show a clear loss of firmness/turgor. The rate of water loss depends on product properties and vapor pressure deficit close to the product. Leafy products like lettuce lose water more easily than e.g. apples or dry onions. Also, specific parts of products such as stems more easily lose water than e.g. the edible parts.

From the interviews it became clear that damage related to moisture loss is hardly an issue for the persons that were interviewed. The reasons are described hereafter.

- It was regarded as no problem that product loses 1,5 – 2 % weight during 2 – 3 weeks transport. In most of the trade the product is sold per box, though the content of the box must be of a minimum weight at the clients'. In order to prevent underweight at arrival most boxes are packed with some overweight. Thus the loss of weight is a kind of hidden damage. Less weight loss during transportation might lead to less weight to pack in the packinghouse, which would result in more packages to sell.
- Most of the containerized products that easily lose water and easily show dehydration are not packed in open boxes, but in boxes with plastic layers or bags. Inside the package the humidity is very high and prevents the product from dehydrating. If in the future the application of plastic might become a problem because of environmental reasons, humidity control might be an alternative solution, although this would not cover the whole chain.
- For some products (e.g. apples and pears) the storage time in containers is relatively short compared to the total storage time. The effect of improvements during the container phase of the distribution chain will have minor effect.

Only in exceptional cases some dehydration damage is observed e.g. dehydrated stems of pears in boxes without plastic layers/bags. Examples of products that are packed in open boxes are mangoes, avocados, stone fruit and pineapples. Mangoes and avocados are usually waxed in the pack house in order to inhibit dehydration during distribution.

3.2 Damage on fruits and vegetables related to too much moisture

Roughly two types of damage are observed to fruits and vegetables due to moisture; stimulation of microbial diseases (fungus, decay) and stimulation of root growth (dry onions).
Microbial diseases usually develop more easily at humid circumstances, especially with 'free water' on the product. Initial infections though, usually take place during cultivation and right after harvest, so the initial quality of the fruits and vegetables going into the containers is very important; 'second class in second class out'. The initial quality varies with growing circumstances and treatments as well as with country, variety, climate, grower etc.

The interviews taught that too much moisture in containers and presumed damage because of the humid conditions is a well-known problem in practice. Symptoms that were mentioned

because of moisture/too humid conditions were collapsed boxes and products that show microbial deterioration *(Botrytis cinerea, Pennicilium, Monilea fructicola etc.).*

Fruits and vegetables that need relatively low relative humidity (65-70%) for optimum storage are sensitive for damage that is enhanced by higher relative humidity. Examples are ginger, garlic and onions. Citrus and stone fruit were also mentioned as being sensitive for development of fungus at moist conditions, citrus especially on the calyx of the fruit. Citrus and stone need a relative humidity of about respectively 85-90% and 90-95% for optimum storage.
The outcome of the interviews was that citrus and stone fruit that are transported in reefer containers regularly show microbal damage on the product at arrival.

Mangoes, avocados, and pineapples, tropical fruits that are very often transported through reefer containers do not seem to be very sensitive for moist conditions. The fruits are packed in open boxes. Waxing the fruits (avocado, mango) in the packinghouse inhibits dehydration.

Relatively high storage temperatures that are optimum storage temperatures for many (sub) tropical products might stimulate development of microbial diseases, because those temperatures are more favorable for their growth. Thus moisture sensitive products that have relatively high optimum storage/transportation temperatures will more easily show damage due to moist conditions than products that are stored at very low temperatures.

Regularly water is observed in the T-bar floor due to blocked drain holes. Some of the persons that were interviewed said that only seldom water is observed in the (open) boxes or on the product inside the boxes. Possible causes for water in the boxes and/or on the products could be temperature differences due to wrong stowage, use of boxes without proper air exchange options, pallets with too little room for air ventilation and conditions outside (temperature and relative humidity) when the container is opened.

3.3 Damaged packages and humidity control

Low humidity is never the reason for damage on packages. Humidity related problems with boxes are always due to moist circumstances. One of the interviewed persons claimed that at arrival 70% of the containers shows at least some collapsed boxes mainly located at the lower layers. Sometimes handling damage or movement of the pallet inside the container seems to be the cause. In many cases though the moist circumstances seem to have effected the boxes. In those cases the strength of the boxes is reduced too much due to over exposure of the boxes to the humid circumstances. The box manufacturer claims that they are well able to deliver a box that can perform under humid conditions during transport. The problem is that a package that has a better performance under humid conditions is more expensive. The box manufacturer stated that the main reason for collapsing boxes is the application of wrong boxes for those specific circumstances.

3.4 Other container issues

Most of the persons that were interviewed complained about the unprofessional stowage of the container and temperature deviations of the cargo from the desired set point. This is often the case even when temperature settings are as desired. Sub optimal stowage might results into sub optimal air movement and thus poor temperature maintenance. Too little air circulation through the pallets and the boxes will cause local rise in temperature of the product because of its own heat production. Usage of packages with sub optimal hole patterns and/or sub optimal stacking on the pallets and application of sub optimal pallets may result into insufficient air movement through the pallets and the boxes. Sub optimal stowage might also result into damage. Empty spaces in the container can result in movement of the pallets during transportation and therefore damage (collapsed stacks).

One of the interviewed persons stated that the products of 20-30% of the containers show local deviations (>3 °C) in temperature from the set point.
South Africa was mentioned as a country of origin that in general does the proper things to achieve optimal transport conditions. For example they adapted the measures of the pallets for avocados and mangoes such that they optimally fit into the reefer containers.

Regularly water is observed in the T-bar floor due to blocked drain holes. Some of the persons that were interviewed said that only seldom water is observed in the (open) boxes or on the product inside the boxes. Possible causes for water in the boxes and/or on the products could be temperature differences due to wrong stowage, use of boxes without proper air exchange options, pallets with too little room for air ventilation and conditions outside (temperature and relative humidity) when the container is opened.

3.5 Knowledge in the distribution chain

The knowledge of the chain partners about optimum requirements per product per container type for packaging, stacking of pallets, stowage of containers very often seems to be inadequate as well as basic knowledge on cooling technique. Optimal arrival starts at optimal departure. Examples that show the lack of knowledge of container users are:

- Topside of pallets is covered in order to prevent cold damage, while the cold air inlet comes from the T-bar floor.
- Application of ethylene scrubbing material combined with ventilation; ethylene-scrubbing material is not useful.
- Ethylene scrubbing material is considered to be moisture absorbing material
- Application of boxes without holes in the bottom, solid based pallets or a closed top side of the pallet which will strongly inhibit air circulation through pallet and/or boxes.

4 Discussion and conclusions

- Low humidity causes weight loss of fruits and vegetables during container shipping especially when the transportation takes place in open boxes. This is not regarded as a problem, though, as overweight is packed at the packinghouse.
- Most of the fruits and vegetables are packed in boxes/packages that prevent dehydration such as liners, consumer packages and/or closed boxes
- Only products that are shipped in open boxes without bag/liner etc. are sensitive to humidity control in the container.
- High humidity may result in free water in the container. This is regarded as a problem. It might enhance development of microbial diseases on the product.
- Box performance is a problem, but this is cost related; use of cheap inadequate boxes causes unnecessary collapsing of the stacks under moist circumstances.
- Inadequate packaging, stowage, pallets, etc cause frequent problems with temperature control/optimum air circulation through pallets and boxes, free water and collapsing of the boxes.
- Products that might be most interesting for improvement of humidity control are citrus and stone fruit that are transported by reefer containers.
- The knowledge in the distribution chain about cooling technique and requirements for packing, stowage, type of pallets etc. regularly seems to be inadequate. Improved knowledge of the key persons in the distribution chain might result into improved application of technical possibilities of a container.

5 Recommendations

For the other subtasks a product and accompanying package and logistic chain has to be chosen. The following recommendations can be made from the information gathered in the chain inventory:

Choice of products for further investigation
Stone fruits (e.g. plums)
Citrus (soft citrus?)
Pineapple

Choice of box
Corrugated box, no top, size 30 cm x 40 cm x 12-25 cm
(We further want to discuss this)

Choice of logistical chain
The chain choice depends on the product choice. For plums the chain will resemble that of mangoes (time to port will be somewhat shorter), which is described hereafter as an example. The typical chain of mangoes from South Africa to The Netherlands is well known at ATO.

Typical chain of mangoes from South Africa to The Netherlands

1. Picking and packing 0-1 day
2. Pre-cooling and accumulation of load 1-5 day
3. Transportation to port 2-3 days
4. Port handling and accumulation of load 0-3 days
5. Voyage time 17-20 days
6. Discharge handling 1-1 day
7. Storage and distribution 0-10 days

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8. Total 21-43 days

Summary

This report is the outcome of an inventory that has been executed in the distribution chain of fruits and vegetables in The Netherlands, Belgium and South Africa. The chain inventory was carried out as part of the research project on humidity control in reefer containers for Carrier Transicold.

Aim of this chain inventory was to list humidity control related problems and humidity requirements of the participants in the distribution chains of fresh fruits and vegetables (with somewhere in the chain transportation with reefer containers).
The chain inventory was made through interviews with
importers/exporters,
the packaging industry,
a survey bureau for fruits and vegetables and
a container terminal and logistical service provider for tropical fruits.

Damage due to dehydration seems to be exceptional. Fruits and vegetables that are sensitive for dehydration are usually packed in protected packages (e.g. box with plastic liner). More often damage of specific products occurs because of too humid conditions. Most sensitive are fruits and vegetables that prefer relatively dry conditions like ginger, onion, garlic (65-70% relative humidity) and citrus (85-90% relative humidity). Diseases cause most damage. Containerized fruits and vegetables that prefer high humidity (90-100% relative humidity) do not often show damage because of too moist conditions according to the persons that were interviewed. Most infections take place during growth or right after harvest. This determines the so-called initial quality of the product. The initial quality is very relevant for further development of diseases. The initial quality varies with growing circumstances and treatments as well as with country, variety, climate, grower etc.
Very often the wrong usage of a package is observed in practice. Some or more of the packages at the lower layers collapse because of insufficient strength of the package for a combination of the specific humid conditions, the weight and the duration of the distribution chain. In addition the interviewed persons complained about cargo which temperature showed significant deviations from the setpoint, damage due to sub-optimal stowage, and the use of wrong pallets and/or boxes that block the optimal air circulation.
Products that might be most interesting for improvement of humidity control are citrus (so called soft citrus might be more often transported by reefer containers than longer storable citrus) and stone fruit (e.g. plums).