Summary of Recent International Transportation Trials

1. Introduction

Conditions of international transport, if poorly controlled, can lead to substantial deterioration in the quality and safety of food products. Given the importance of this issue, the European coffee industry OTA Task Force has carried out a number of trials to investigate the impact of international transport of green coffee on risk of OTA contamination. As these trials are highly relevant to work of the global coffee project, the OTA-Taskforce has made the results of their trials available to the project. What follows below is a brief description of these trials, as provided by the coffee industry task force, and outlining their main conclusions.

Two additional international transportation trials were carried out in collaboration with the FAO/ICO/CFC project during mid-2005. Once the data has been processed the results will be made available on the FAO project website (www.coffee-ota.org [www]).

Simulated transport trials were also carried out under the FAO/ICO/CFC project in collaboration with FUNDEPAG, São Paulo, Brazil. These trials are designed to investigate the influence of the ‘fill level’ of the container on risk of condensation and hence rewetting of coffee. The results of these trials will also be available on the project website by the end of 2005.

Further information can be gleaned by consulting the specific references that are provided in the selected bibliography contained within Section 3 of this CD-ROM.

2. Coffee Industry OTA-Taskforce International Transportation Trials

The OTA-Taskforce executed a number of international transportation trials. As there was limited information available to the Taskforce at the beginning of this exercise, a very practical approach was followed. The first trials simply recorded changes in conditions of temperature and relative humidity within the containers during transportation. In the later trials certain measures for preventing the rewetting of coffee by condensation were also investigated. The trials monitored temperature (T) and relative humidity (RH), as they are the main variables affecting potential for mould growth and OTA production during this stage of the coffee chain. The automatic recording of these variables using probes also overcomes practical difficulties associated with sampling within the container.

As of mid-2005, the industry task force had completed five (5) container transportation trials. The OTA-taskforce plans to make the results of these trials widely available through scientific publications.
**Trial # 1:**
A container with Uganda robusta in bags was kept for 30 days (February/March 1999) in the open air at the dockside in Rotterdam harbour.

After arrival monitoring devices (T + RH) were positioned at five different spots in the container. Monitors placed ‘one bag deep’ into the coffee stack at the rear, middle and door-end of the container showed a steady but gradual change in T and RH over time, with T gradually decreasing and RH gradually increasing.

On the other hand, monitors placed midway along the length of the container (on the surface of the coffee bags and the one taped to the roof) showed very marked day/night fluctuations, with T varying between ~ 5°C and ~35°C and RH exceeding 95% on several occasions. A total 10 hours of condensation on 9 different occasions were registered – these all occurred early in the morning. Samples were taken from the front row of bags directly behind the door at beginning and end of this trial. Mean moisture content at start was 13.6% and at the end 14.4%. The OTA levels did not differ beyond analytical accuracy.

Within the coffee stack, T and RH change slowly and moisture also only moves slowly. Nevertheless, there are very clear differences in spot moisture contents. However, in the headspace over the coffee, the fluctuations show a day/night pattern and are much more pronounced.

**Trial # 2:**
In the second trial, two monitors were placed in a container at the point of stuffing of the container in Kampala, Uganda with coffee in bags to be transported to Bremen, Germany (December 1999/January 2000).

Walls of the container were lined, but there was no cover over the stack of bags in the container. One monitor was taped to the roof and the other one was placed under the first layer of bags in the stack of coffee. As with the first trials, T and RH within the stack of coffee changed only slowly. The monitor taped to the roof registered strong day/night fluctuations both during transport from Kampala to the port in Mombassa, and after arrival in Bremen. A maximum T of 50°C was reached during terrestrial transport from Kampala to Mombassa. Values for RH of 100% were reached both between Kampala and Mombassa and after arrival in Bremen. The T and RH fluctuations during maritime transport were relatively small. However no information is available about the actual position of the container on the vessel while sailing.

This transport trial illustrates two particular situations during transport from Kampala to Mombassa:

- Two rather long periods of time (7 hours) at temperatures above 40°C - up to 50°C – and at 60% RH at the top of the coffee.
- One short period of condensation (2 hours), in the morning, after a temperature minimum of 13.5°C.
Therefore, there was a significant risk of damage due to dramatic T and HR increases during transport from Kampala to Mombassa, especially for the coffee in the top-layer of the containers.

**Trial # 3:**
In this trial, three monitors were placed in a container with Uganda robusta coffee in bulk. The transport was from Kampala to a European harbour and left at the quay for an additional 9 days (May/July 2000).

In this trial, a liner was placed over the bulk coffee. One monitor was located on top of the liner, another was placed inside the liner on top of the coffee and a third was placed at a depth of 30cm in the coffee. The results of this trial are quite similar to those of the second trial, but without condensation and less extreme conditions. The highest RH in the headspace was reached during over-land transport from Kampala to Mombassa (85%). No condensation was observed during the 9 day period of waiting on the quay in Europe.

This trial suggests that there are less extreme fluctuations of temperature and RH in the case of bulk transported coffee than with bagged coffee in containers. The absence of condensation during delay at the quay in Europe might be partly explained by the fact that it was summer.

**Trial # 4:**
Two containers of coffee were monitored during transport from Santos/Brazil to Rotterdam /Netherlands (November 2000/January 2001).

One container contained bulk and the other bagged coffee. The monitors were positioned within the stack of coffee, on top of coffee, and for the bulk coffee a third monitor was placed on top of the liner.

The fluctuations observed in this trial were mostly minor with one exception when the RH on top of bags once reached 90%.

This journey did not include long periods of overland transport.

**Trial # 5:**
Four containers with Vietnam coffee in bulk were equipped with different arrangements of drying bags. Inside walls and roof were covered with cardboard and the coffee was contained in a plastic liner. Monitoring devices were positioned inside the coffee stack, on top of the coffee, on top of the liner and behind cardboard taped to the roof.

The use of dry bags can help to reduce the RH in the headspace significantly, thereby reducing the risk of condensation damage.
3. Overall Findings:

Monitoring temperature and RH at various locations in containers of coffee has shown that the roof and headspace appear to be the most risky places with respect to condensation. The maritime leg of the international transport seems to cause the least problems, provided the container is positioned below deck or at least not directly exposed to sunlight.

There is also limited evidence that fluctuations of RH are less extreme in the case of bulk coffee in containers. This tentative finding is also corroborated by reports within the industry of greater complaints of quality deterioration in the case of bagged coffee transported in containers. Stuffing the bags in saddle-stow instead of the conventional bags on top of each other resulted in fewer transport damages.

4. Recommendations of the Coffee Industry Task Force:

The available Brazilian and OTA-Taskforce results on containerised transport, both national and international, are sufficient to draw up guidelines for measures to reduce risks of condensation, re-wetting and mould growth during this stage of coffee transport.

Evaporation of moisture from the green coffee can be limited by:

- Ensuring a maximum moisture content of green coffee of 12.5% at stuffing;
- Protecting coffee from rain at stuffing;
- Using so-called saddle stow to reduce air circulation between the bags when coffee is being transported in bags in container;
- Minimising delays during overland transport and limiting direct exposure of the container to sun;
- Preferably stowing below deck.

Condensation at cold spots and rewetting of the coffee can be limited by:

- Covering of the walls of the container with paper sheeting;
- Covering heaps of bags in the container with a paper or water-absorbent sheeting. This will limit rewetting of the coffee by any condensation dripping down from the ceiling (in bulk the liner will perform the same task);
- Minimising delays during terrestrial transport, and limiting exposure of the container to night-time cold;
- Emptying the container upon arrival at the final destination as soon as possible.
Fig. 1: Relative Humidity and Temperature readings from Trial # 2 - Kampala to Bremen (bags in container)