HDC

Iceberg lettuce: monitoring temperature and carbon dioxide in bulk loads during long distance transport

FV 198a

David Gray, Roy Drew and David Hart

Project Title:	**Iceberg lettuce: monitoring temperature and carbon dioxide in bulk loads during long distance transport**
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Project Leader:	**Dr D Gray** **Head, Crop & Weed Science Department** **Horticulture Research International** **Wellesbourne, Warwick** **CV35 9EF**
Project Staff:	**Mr Roy Drew, Crop & Weed Science Department** **Mr David Hart, Facilities Department**
Location:	**HRI, Wellesbourne**
Project Co-ordinator:	**Mr D Langmead through Stuart Campbell**
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1. PRACTICAL SECTION FOR GROWERS

Objectives and background

An HDC sponsored review of published literature, FV 198, identified the conditions during transport influencing shelf-life.

The findings from this were that storage life and quality were prolonged by:

- temperatures in the range 0-2.5°C
- carbon dioxide levels in the hull of the lorry below 10% (10,000ppm)
- ethylene levels below 1ppm

Temperatures, CO_2 and ethylene levels higher than these values induced russetting of the tissue.

The objective of the work was to identify the storage conditions in transit in lorries during export of Iceberg lettuce to Southern Europe from summer/autumn harvested crops grown in the UK.

Using carefully checked and calibrated equipment, assembled by HRI, the work identified that the temperatures during transport frequently exceeded 2.5°C. It was clear that independent monitoring of temperature is necessary and that reliance on the data from control sensors is an unsatisfactory guide to temperature in lorries.

Carbon dioxide concentrations consistently exceeded 10,000 ppm. Ethylene levels were not monitored as no suitable, cheap (less than £3000), reliable monitoring equipment is available on the market.

Product delivered to market in Italy as assessed by the co-operating grower (D.Langmead) quality control staff had developed brown discoloration and russetting which may be related to the storage environment encountered.

The work has indicated that there could be problems in maintaining an adequate post-harvest environment during transport. Further work is needed to quantify the effects on post harvest quality of the degree and duration of unsatisfactory storage conditions and whether this is influenced by the method of crop production, time elapsed between harvest and vacuum cooling and the rate of cooling.

2. INTRODUCTION

Since 1991 exports of lettuce, primarily Iceberg have risen from 0.5 to 4.2 thousand tons with an estimated value of c £3m. There are opportunities to expand this market but this will depend upon delivering good quality lettuce following shipping in refrigerated lorries for 2-3 days.

A review **FV 198 Iceberg lettuce: improving post-harvest quality,** identified that the quality is dependent upon maintaining the environment in the hull of the lorry:

1) in the range 0-2.5°C

2) below 1% (10,000ppm) CO_2

3) below 1ppm ethylene (C_2H_4)

The objective of this project was to monitor the environment of lorries loaded with lettuce transported for a two to three day period during shipment to mainland Europe assessing the quality of lettuce prior to despatch and on delivery.

3. MATERIALS AND METHODS

General

Several growers throughout the UK agreed to participate in this project but because of considerations of either distance from HRI Wellesbourne or length of the export journey time, Langmeads, Walnut Tree Farm, Runcton, Chichester was chosen as the grower co-operator on the project. The grower choice was made on: i) the need to be both close enough to HRI so that at short notice it was possible to travel to install equipment in the lorry for each export run, ii) to have an export destination sufficiently far away as to allow 2-3 days transport time and iii) a destination in Southern Europe to ensure a high ambient temperature. Export runs to Padua, N. Italy, a trip of 2-3 days, were made on two occasions: on the first, the vehicle departed at 12.00 noon on 15th September and arrived in Padua 16.00, 17th September. On the second, the vehicle departed 16.00 on 13th October and arrived at 23.00h on 15th October. At despatch the vehicle storage temperature was claimed to be 3°C. Details of the crop history for each of these runs are given in the Appendix.

Monitoring the environment

The monitoring equipment used was assembled by Mr David Hart in a pair of cardboard boxes with the same dimensions and air hole patterns as the lettuce boxes used and it was installed by Langmeads staff to HRI instructions in the middle of a pallet of lettuce in the hull of the vehicle.

Temperature was measured using a thermistor (accuracy 0.2°C) and humidity was measured using a thin film polymer capacative type sensor (accuracy 2%). CO_2 was measured using an Analox Infrared sensor (IRS5) with a range 0-10,000 ppm. The outputs were monitored using a Data Hog2 SDL5160 (Skye Instruments). Both instruments were battery powered, the Data Hog having its own internal 1.5v batteries and the CO_2/temperature unit being run from two 6v sealed rechargeable batteries. The CO_2 analyser was checked against reference gases at 350ppm and 5000ppm and calibrated before each run. Temperature and humidity were checked against reference 5°C and 90% rh, respectively, and again calibrated prior to each run.

A search was made for suitable, cheap ethylene monitors (<£3000) but none were available with the required sensitivity.

Vehicle contents

On the first run, the load was a mixed one with six pallets of cauliflower, three punnets of strawberries and the rest lettuce of various types including the experimental material. The temperature and CO_2 analyser was situated eight pallets from the front of the vehicle. On the second run the load was solely lettuce of various types.

4. RESULTS

Run 1:

The published literature (see FV 198a) indicates that temperatures of 0-2.5°C are best for the transport of lettuce though there are reports that storage at 4°C is suitable for Iceberg lettuce. Fig 1 shows that during the transport period, temperatures were frequently outside this range. Whether the departures from the set temperature in the vehicle (claimed to be 3°C) were due to external environment or switching off the diesel generator are not known. Fig 2 shows humidities in the vehicle which ranged from 65-95% and these generally reflected minor changes in temperature. Fig 3 shows the carbon dioxide concentration in the vehicle, which on sealing the doors, rose rapidly to exceed 10,000 ppm, the concentration known to induce rib russetting.

The reason for the fall in CO_2 concentration at 8.00 am on 17 September is unknown but may be associated with opening the doors for a Customs and Excise Inspection. The QA reports (Table 1) on delivery report significant browning in the outer two leaves at the base.

Run 2:

Fig 4 shows that temperatures consistently exceeded 5°C throughout transport. Fig 5 shows that rh increased gradually throughout the transport period from c. 65-70% to 75%. Fig 6 shows that carbon dioxide concentration increased rapidly from 400 ppm to over 10,000 ppm in 12hr of transport and it remained at this level until about 3h before the crop was unloaded.

QA analysis indicated a slightly higher level of breakdown compared with run 1 on despatch but not significantly noticeable browning compared with run 1 on delivery.

5. DISCUSSION

The published literature indicates that for maintaining quality lettuce over a three day transport period or longer

- temperatures should ideally be in the range 0-2.5°C
- carbon dioxide concentrations should not exceed 1%

Higher temperatures and CO_2 concentrations will enhance the development of browning of the tissues, particularly if the rib or leaf tissue is damaged at harvest. Despite the claims of the lorry drivers the set temperatures of the lorries were not maintained at 3°C and they were frequently above this especially on the second run. Our sensors were checked and calibrated prior to and after each run. This highlights the need to use **regularly calibrated sensors independent of the control sensors for monitoring environments.**

The concentration of CO_2 in the lorries consistently exceeded 10,000 ppm and this may have contributed to the browning of the tissue observed. In view of the higher temperatures in the lorry in the second run a higher level of browning might have been expected compared with the first run but many other factors associated with differences in the composition of the loads (Run 1 was a mixed load) and the history of the crop complicates the comparison.

For example, the mixed load in run 1 could have generated extremely high CO_2 levels which could not be accurately measured as they would have been outside the range of the sensor.

6. CONCLUSIONS

The study serves to demonstrate that during transport of lettuce for export

1) the claimed environments are not being achieved

2) the environment may vary throughout the period of transport

3) environmental conditions, which the literature indicates prolong storage life and quality most effectively, are not reliably achieved.

Further work is needed to quantify the effect on post-harvest quality of Iceberg lettuce of the degree and duration of storage conditions and whether this is influenced by the method of crop production, time elapsed between harvest and vacuum cooling, and the rate of cooling.

Table 1

	Run 1	Run 2
Average Head weight (g)	**738**	**740**
QA at despatch		
% damage	10	10
% breakdown	8	15
QA on arrival	Rib browning present on two outer leaves	Pink and brown ribs present on nearly all lettuce No significant butt browning

7. APPENDIX

Appendix 1

		Run 1	Run 2
		(Batch 98G rows 177-182)	(Batch 113)
Variety	:	data not given	data not given
Planting date	:	28/7/97	15/8/97
Harvest date	:	14/9/97	13/10/97
N P K Fertiliser ($kgha^{-1}$)	:	67 : 49 : 137	71 : 39 : 110
Top dressing N:		33	33
Vacuum cooling:			
Duration (mins)		data not given	25
Temperature in °C			12
Temperature out °C			3°C
Overwrapping Material		Standard polypropylene	

Fig. 1. Temperature, Run 1.

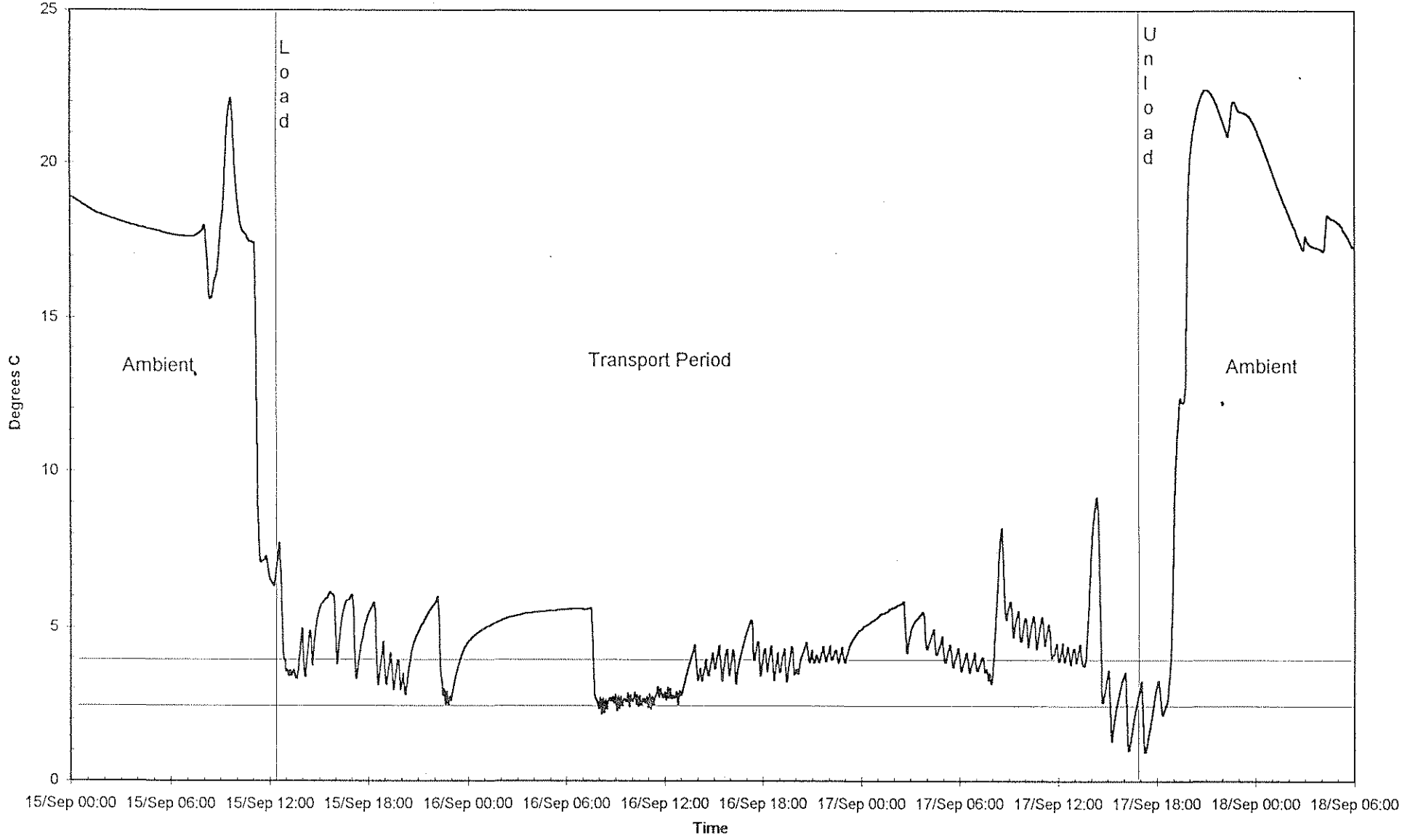

Fig. 2. Relative Humidity, Run 1.

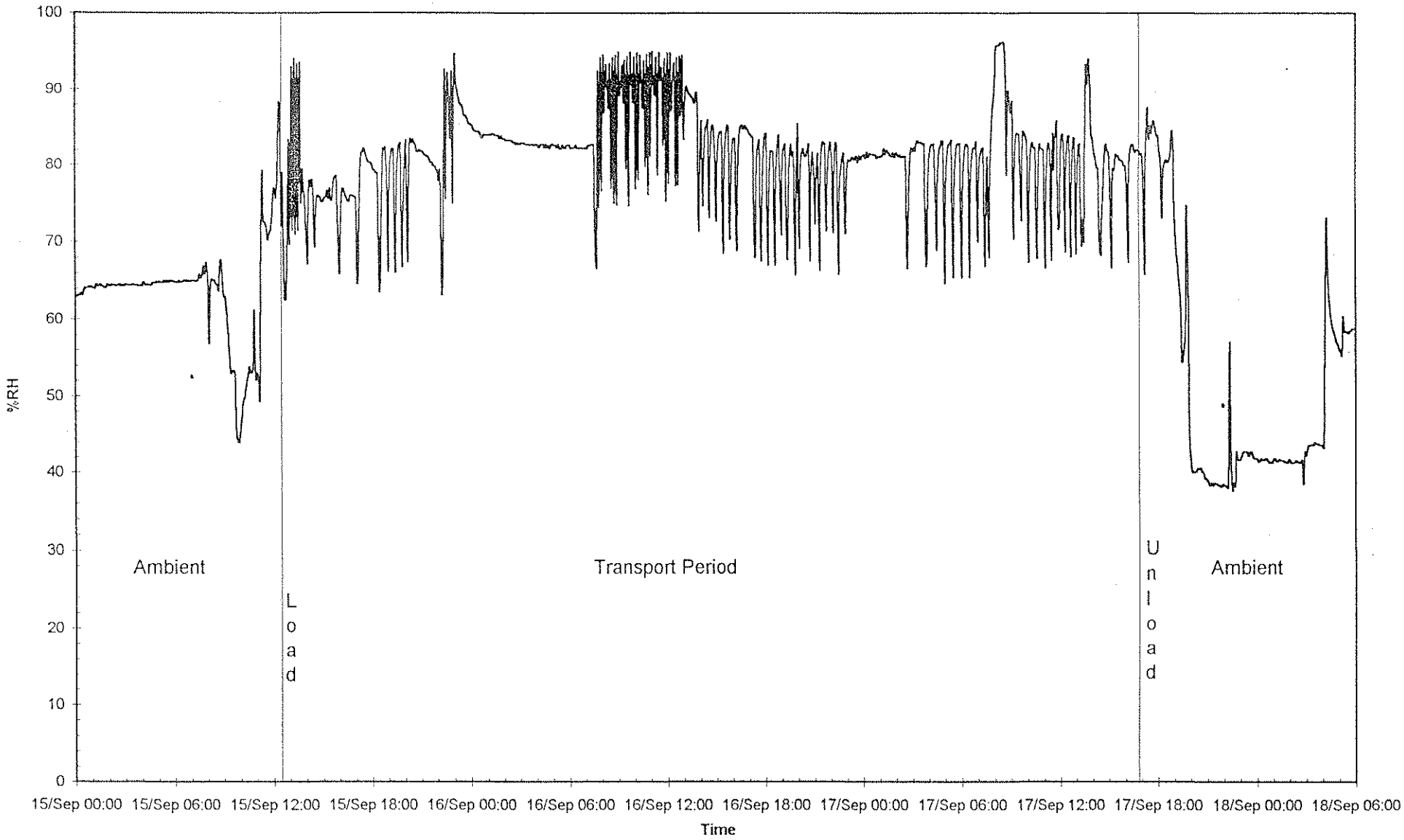

Fig. 3. Carbon Dioxide Concentration, Run 1.

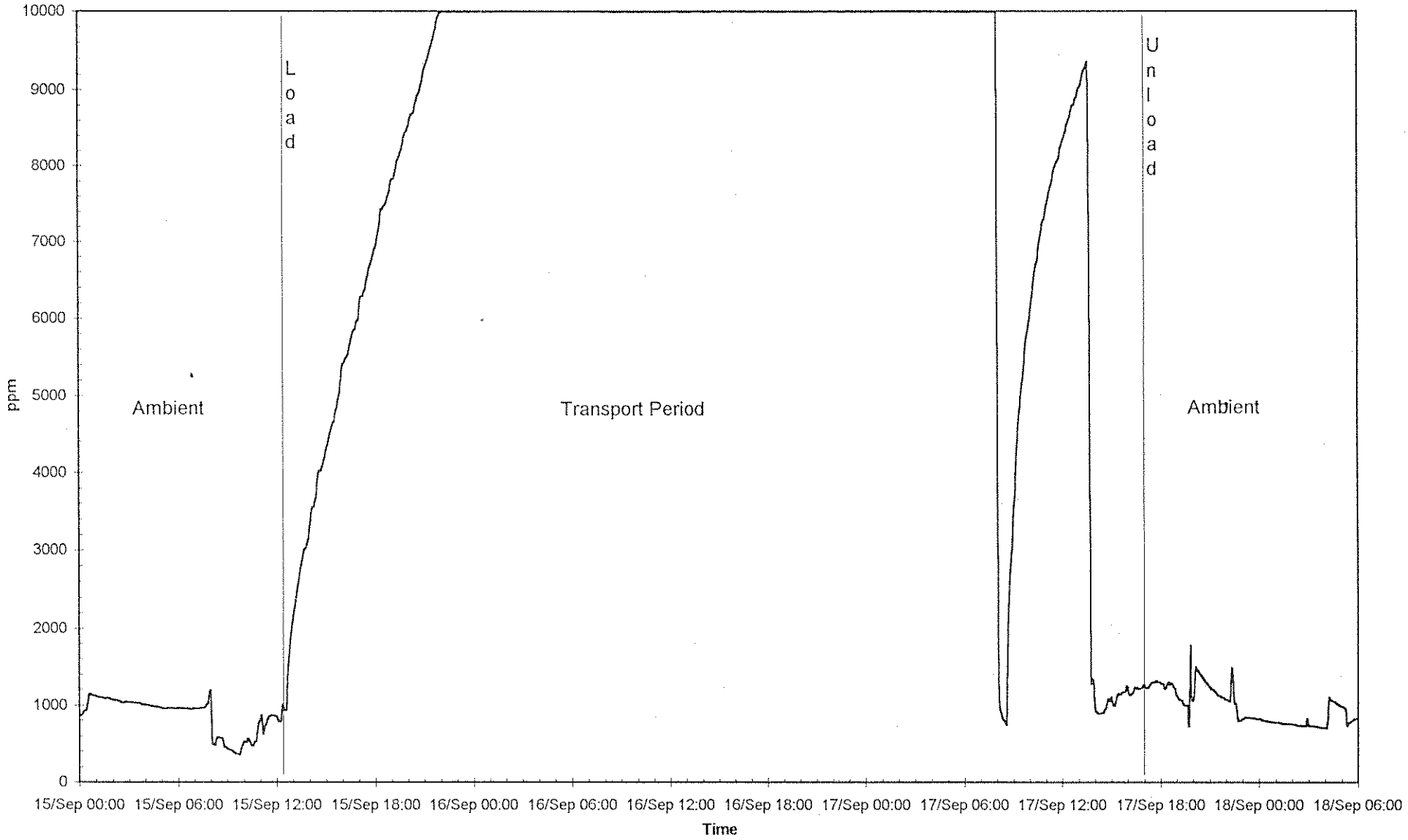

Fig. 4. Temperature, Run 2.

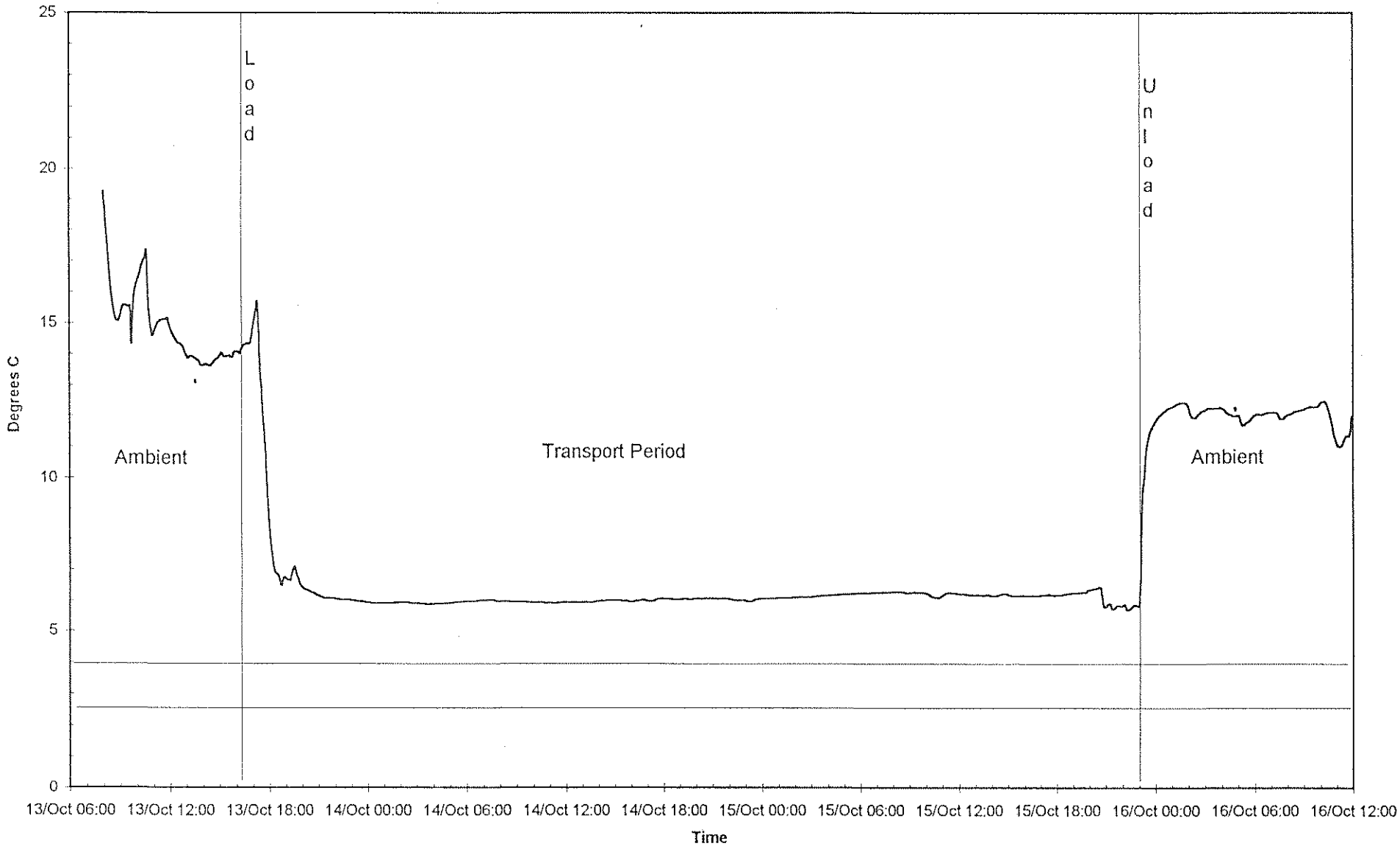

Fig. 5. Relative Humidity, Run 2

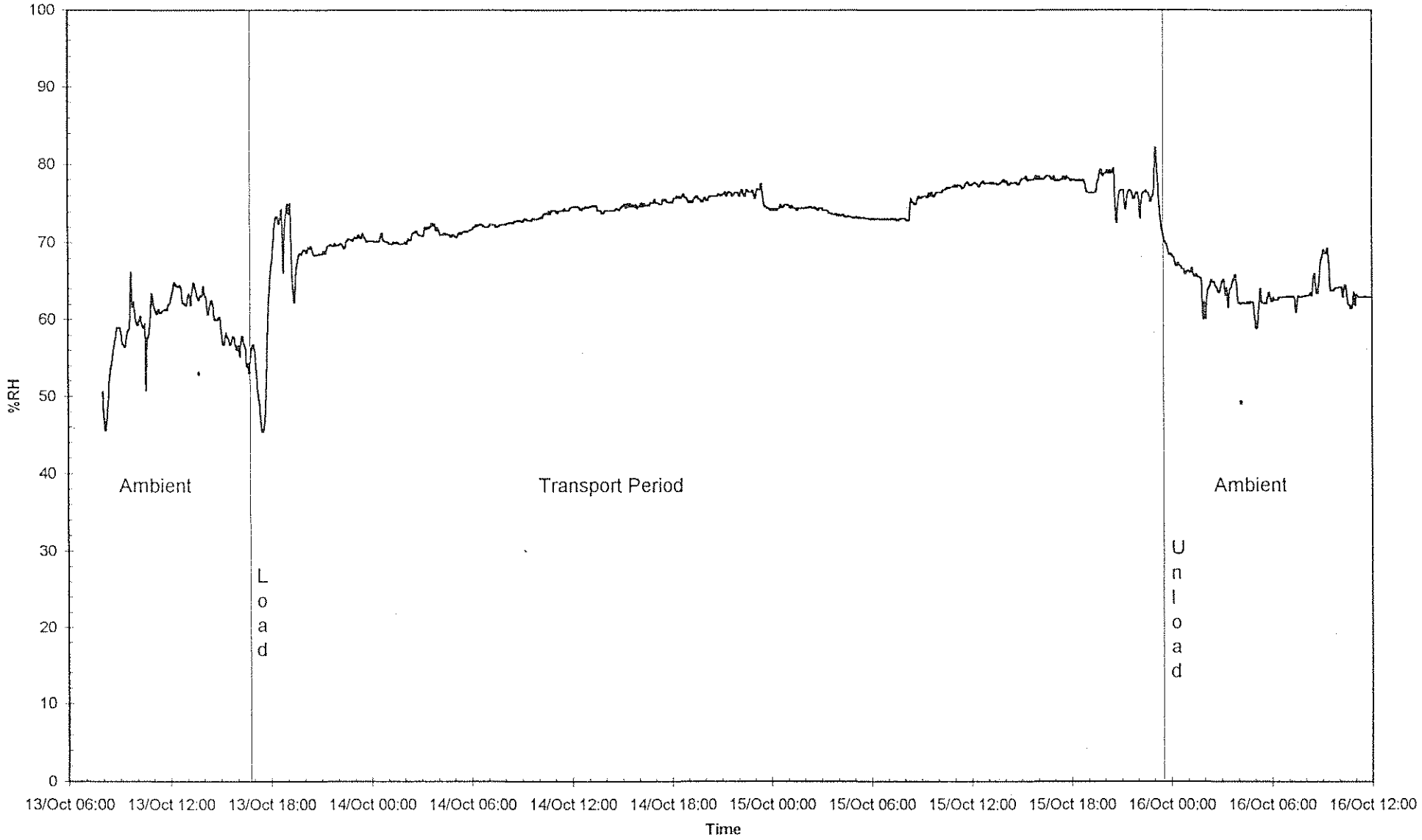

Fig. 6. Carbon Dioxide Concentration, Run 2.