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Working Party on the Transport of
Perishable Foodstuffs
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PROPOSALS BY THE RUSSIAN FEDERATION

The present document has been prepared at the request of the Working Party on the Transport of Perishable Foodstuffs (TRANS/WP.11/1997/CRP.1, para. 85, 24 November 1997) for the purposes of the examination at the forthcoming session of conditions for the transport of fresh fruit and vegetables, with a view to their inclusion in the Agreement on the International Carriage of Perishable Foodstuffs and the Special Equipment to Be Used for Such Carriage (ATP).

INTRODUCTION

The special features of the transport of fresh fruit and vegetables

The length of the rail journeys involved is one of the principal features of the transport of fresh fruit and vegetables in Russia and the CIS countries.

In the case of Russia, the average lengths of rail journeys in 1995-1997 were: for potatoes, up to 1,500 km; for fruit and berries, up to 2,600 km; for apples, up to 2,800 km; for citrus fruit, up to 3,000 km.

In 1997, the average distance of carriage of these foodstuffs was from 200 to 680 km greater than in 1996.

Moreover, such trips, which can take up to 20 days, entail the crossing of 3-4 time zones and a variety of climate zones. In autumn/winter and spring/summer, fresh fruit and vegetables are carried through areas with maximum and minimum ambient air temperatures of +40 °C and -40 °C respectively. Attention to the following points is essential to prevent deterioration of the produce:

The quality of containers and packages;

The correct placement of the goods in the vehicle;

Ventilation;

Temperature control and trip duration.

The conditions for the carriage of fresh vegetables, fruit and citrus fruit differ according to:

The time of year (summer, winter or inter-seasonal period);

The temperature adjustment prior to transport (pre-cooling or not);

The type of vehicle (refrigerated, insulated or ordinary, uninsulated).

On the basis of the above factors, Rules of Carriage specify for each type of produce the maximum trip duration, the temperature range to be maintained in the vehicle, the duration of heat treatment of the cargo during carriage, the stowage pattern and height, and the ventilation of the vehicle (tables 1 and 2).

Bananas, oranges, mandarins, lemons, grapefruit, apples and potatoes have long been among the world's most heavily traded fruits and vegetables. Bananas and citrus fruit (oranges, mandarins, lemons and grapefruit) are grown in tropical and subtropical zones on both sides of the equator in central and southern America, Africa and South East Asia, while apples and potatoes are grown in the central belt of Europe and Asia.

There has recently been a particular increase in export shipments of Cavendish and Gros Michel bananas, these varieties being capable of withstanding lengthy transport and storage. There is also carriage of other varieties of bananas (Lakatan, Robusta, Valery, etc.).

The need to establish rules for the international carriage of fresh fruit and vegetables derives from the biochemical and physical properties of the produce, the increase in journey times, the widening of the range of produce carried, etc. As a result, conditions need to be set for all stages of carriage in the export/import of fresh fruit and vegetables.

In recent years, the Russian Railways Ministry has undertaken extensive research in connection with the laying down of conditions for the carriage of fresh bananas, apples, potatoes, citrus fruit and grapes.

Their many investigations have shown Russian specialists in storage and transport that carriage needs to be effected at the following temperatures: for mandarins, oranges, Star Ruby grapefruit, late apples for winter storage and potatoes, between +2 and +6° C; for other grapefruit, between +7 and +13° C; for lemons, between +6 and +9° C.

The All-Russian Rail Transport Institute and Russian Railways have jointly conducted research into the conditions for the carriage by rail of fresh bananas.

Main features of the research methods

The research was carried out in two stages:

Stage 1: Experiments in a fixed chamber;

Stage 2: Verification of results of stage 1 by trial journeys in real-life conditions.

Stage 1: Experiments in a fixed chamber

The time limit for the carriage of bananas by rail is taken as the bananas' remaining "life" from the time they are unloaded from the ship to the time they reach the highest stage of edible ripeness minus the time needed for their sale (which runs from the time the vehicle is unloaded to the time the product is sold to the consumer).

The following variables were simulated in a fixed chamber:

Temperature range;

Stowage (stacking) of the boxes of bananas;

Fan operation;

Ratio of the full volume of the cargo space to the volume of the cargo stack assuming full use of a wagon's load space;

Quantity of external air admitted and frequency of ventilation of the cargo space;

Frequency of ventilation.

The temperatures of the bananas and the air were measured every four hours.

The experiment was considered over on the day when the bananas appeared to have reached the highest stage of edible ripeness (presence of brown spots on their skin).

Stage 2: Procedure for trial journeys

The trial journeys were made with the aim of verifying the conditions for the transport of bananas in refrigerated wagons.

The aim was to ensure that use of the predetermined temperature ranges, stacking patterns and frequency of ventilation delayed deterioration of the fruit for the required period of time.

The refrigerated wagon in which the trial journeys were made was either pre-cooled or pre-heated to a temperature of +11° C.

The degree of ripeness of the bananas and the percentages of green, yellow and rotten fruit were determined directly in the boxes (relative to the number of pieces of fruit or the mass of the fruit).

Results of the experiments in a fixed chamber

The fruit used for the fixed-chamber tests were fresh "Cavendish" bananas packed in "bonavac"-type polymer film bags inside cardboard boxes 50 cm long, 41 cm wide and 24 cm high.

The cargo space of the wagon and of chamber No. 1 was ventilated for 20-30 minutes every 24 hours.

During the first few days the bananas were in the wagon, the average temperature (figs. 1 and 2) inside boxes A2, A3 and A6 was within the range +12.4-13.9° C, while in boxes C and D, where there was a "saboteur" (a bunch of yellow fruit), it was between +14 and +14.5° C. It subsequently rose strongly, reaching +19-23° C by the end of the test (23 days in the wagon).

The rise in the temperature in the boxes can be attributed to spontaneous ripening of the bananas once the temperature of their pulp passed the +14.5° C point.

The amount of heat given off by bananas increases until they reach a degree of ripeness corresponding to the 3 mark on the chromaticity scale, after which heat emission declines, falling sharply with the passage from the sixth to the seventh degree of ripeness.

In the test chambers, the air temperature was below the ripening threshold (+13-14 ° C), so that yellowing of the bananas began somewhat later.

After 18 days in the wagon, there were only 7 boxes (25%) of the total 28 in which the ripening process had not begun or was at an early stage (fig. 3).

To determine how high boxes of bananas can be stacked, two stacks were made: one was 192 cm high (8 boxes) and the other 168 cm high (7 boxes) and an additional load of 101.5 kg was placed on each. The total mass of the first stack was 261.5 kg (equivalent to the mass of 13 boxes) and the total mass of the second 241.5 kg (equivalent to the mass of 12 boxes). The pressure on the bottom box in each stack was 241.5 and 221.5 kg respectively.

The criterion for the choice of stacking height was the absence of deformation of the boxes and fruit in the bottom tier of the stack.

Subsidence of the stack simulating 9-high stacking amounted to 1.8 cm after 4 days, with no subsequent change. Subsidence of the stack simulating 8-high stacking amounted to only 0.4 cm. There was no apparent deformation of the boxes.

Hence, banana boxes are strong enough to withstand being piled 9-high in a compact stack in a refrigerated wagon. The height of a 9-tier stack is 2.12-2.16 m.

Results of the trial journeys with bananas

The results of the static tests were checked by making trial journeys using 5-wagon refrigerated sections. A total of 14 such sections were run in winter and 20 in summer, making 34 journeys with 4 wagons each (136 wagons).

In winter, the wagons' load space was heated before loading, and in summer it was cooled.

The boxes of bananas were mainly placed vertically in compact stacks. Upon shipment from storage bases, other placement patterns were used (chequerboard pattern).

Stacking the boxes 10-high caused some deformation of the lower boxes, without physical damage to the boxes or the fruit inside them.

Stowing the boxes of bananas chequerboard-fashion yields no benefits as regards maintenance of the desired temperature range in the wagon and sharply diminishes the stability of the stacks during transport.

The bananas were loaded into wagons previously cooled to +13-14° C. During the trial journeys, the temperature in the wagons was held at +11-13° C.

The results from the trial journeys (fig. 4) show that, for journeys of approximately equal duration, the percentage of bananas which had turned yellow by the end of a trip was higher in the winter than in the summer (averages 4.0% and 2.1% respectively). The percentages of yellow bananas averaged: for a journey of 10-14 days' duration, 8.8% in winter and 6.7% in summer; and, for a journey of 7-9 days' duration, 3.3% in winter and 0.2% in summer. On the other hand, for a trip of 3-5 days' duration, the yellowing rate was higher in summer (1.1%) than in winter (0.1%).

It is also noteworthy that, again after journeys of approximately equal duration, the proportion of boxes containing yellow fruit was higher when the bananas had been loaded from ship to wagon via a transshipment depot (5.3%) than when they had been loaded straight from ship to wagon (3.0%).

In refrigerated wagons with compact stacks of boxes, there was a gradual rise in the temperature inside the polyethylene bags containing the bananas. This was due to the natural ripening of the fruit.

Given refrigerated wagons in which the air temperature in the load space is maintained within the range +11-13° C and assuming the maximum acceptable proportion of yellow bananas at the end of the trip to be 25-30%, the maximum permissible duration of carriage of green Cavendish bananas in bags made of "bonavac"-type polyethylene would seem to be 15 days. The corresponding figure for bananas packed in bags made of "polypack" film would seem to be 5 days.

CONCLUSIONS

1. The investigations showed that fresh bananas presented for rail transport from ports after 17-20 day sea voyages are at differing stages of the preclimacterium, even though they may all exhibit the same green colour. That being so, it seems impossible to predict how fast they will ripen after being accepted for transport.

2. Continuation of the present practice of holding the air temperature in refrigerated wagons within the range +11-13° C can be recommended for the transport of bananas, since the temperature in the fruit is generally higher (+12-14° C).

3. It is recommended that boxes of bananas be stowed in compact 9-high stacks (2.12-2.16 m).

4. To maintain the quality of bananas, it is recommended that they should not be carried by rail for longer than the following periods:

If packed in "polypack" film: 5 days;

If packed in "bonavac" film: 15 days.

In such circumstances, a shipment should not contain more than 10% of yellow bananas on arrival at the destination station.

5. Bananas are very sensitive to temperature changes and ethylene content. A temperature of less than +11.5° C can cause chilling injury, while a temperature of more than +14.5° C causes accelerated undesirable ripening (yellowing) of the fruit.

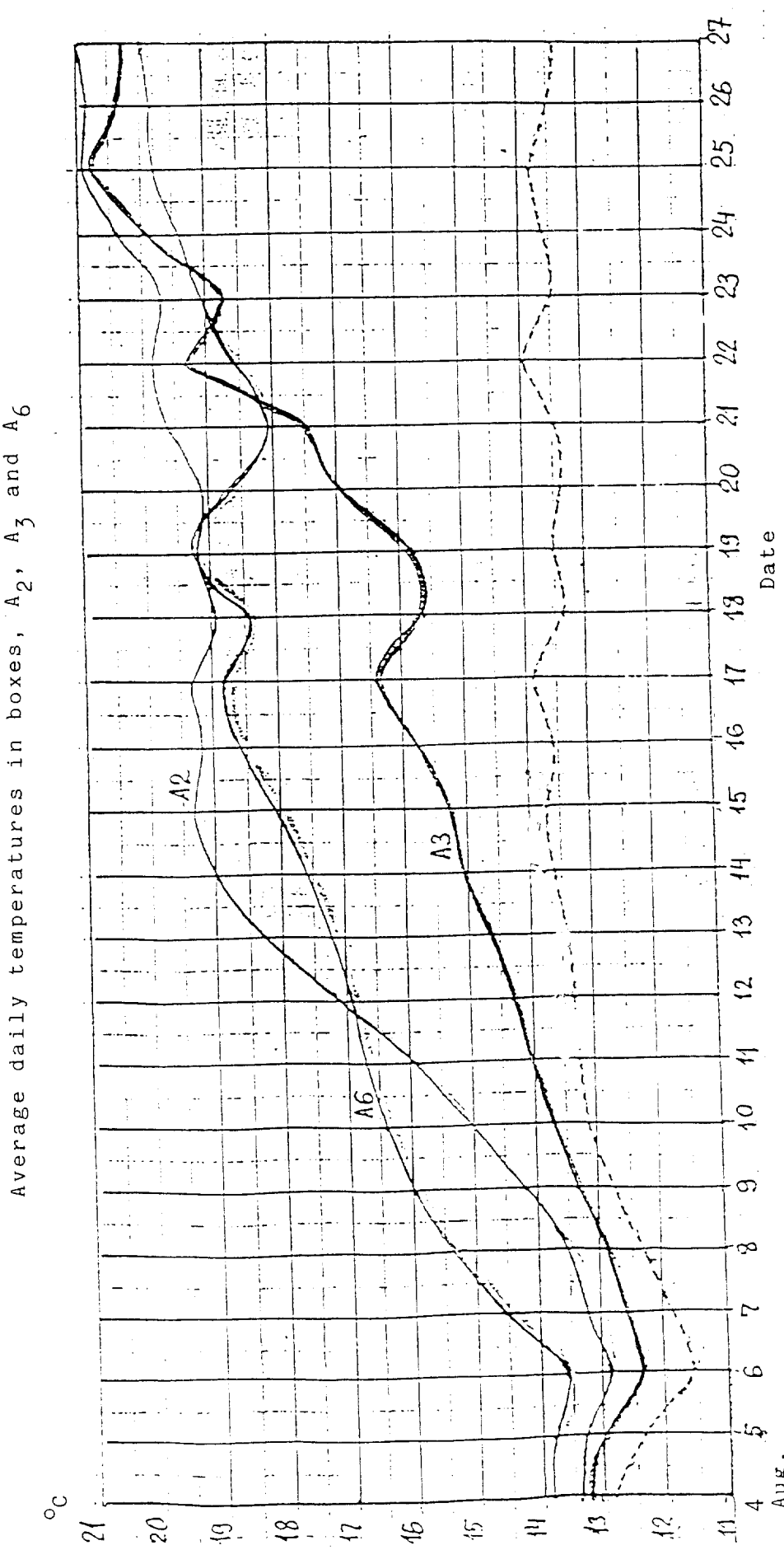
Thanks to their thick skin, bananas in the "Gros Michel" groups are less sensitive to chilling and keep their initial qualities at intra-fruit temperatures of between +11.5 and +13° C. Because of their thin skin, varieties in the "Cavendish" groups are more sensitive to chilling; for them, a temperature of +12-14° C is preferable.

The research showed that the temperature in the pulp of fresh unripe bananas carried in a temperature-controlled vehicle generally exceeds the temperature of the surrounding air.

6. All varieties of bananas require forced air circulation to maintain an even temperature throughout the stack, as well as the admission of fresh air (ventilation) in order to prevent the accumulation of ethylene and consequent premature ripening of the fruit.

7. To reduce the ethylene concentration, bananas can be packed in polyethylene film the inner surface of which is covered with an ethylene-absorbent layer. This almost doubles their storage and transport lives.

8. The delegation of the Russian Federation considers that conditions for the transport of fresh fruit and vegetables should be included in ATP. That would help to resolve the problems relating to the quality and life of the produce during international carriage.


Average daily temperatures in boxes, A_2, A_3 and A_6
°C
21
20
19
18
17
16
15
14
13
12
11
A2
A3
A6
4
5
6
7
8
9
10
11
12
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26
27
Aug.
Date

Fig. 1

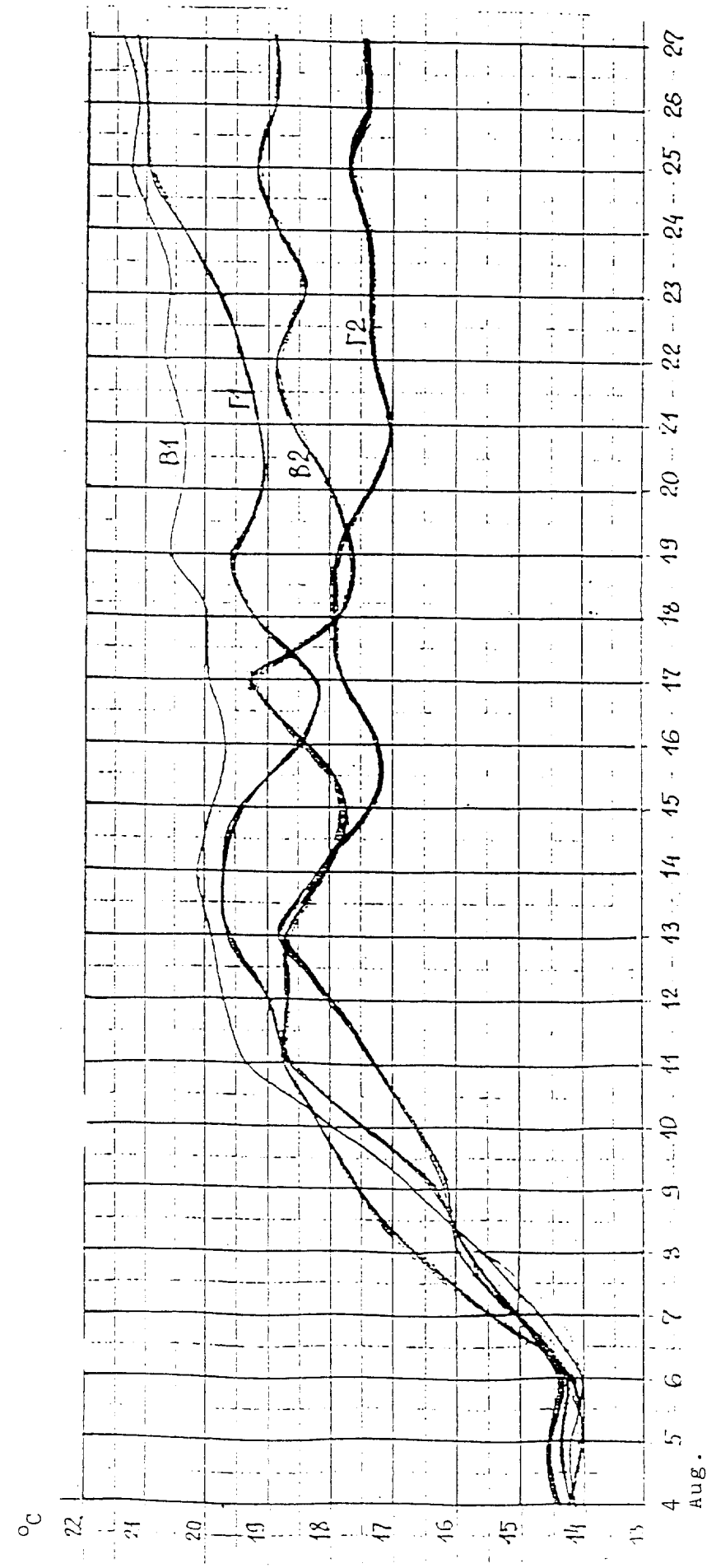

Average daily temperatures in boxes C_1 and C_2 and D_1 and D_2
°C
22
21
20
19
18
17
16
15
14
4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
Aug.
B1
Г1
B2
Г2

Fig. 2

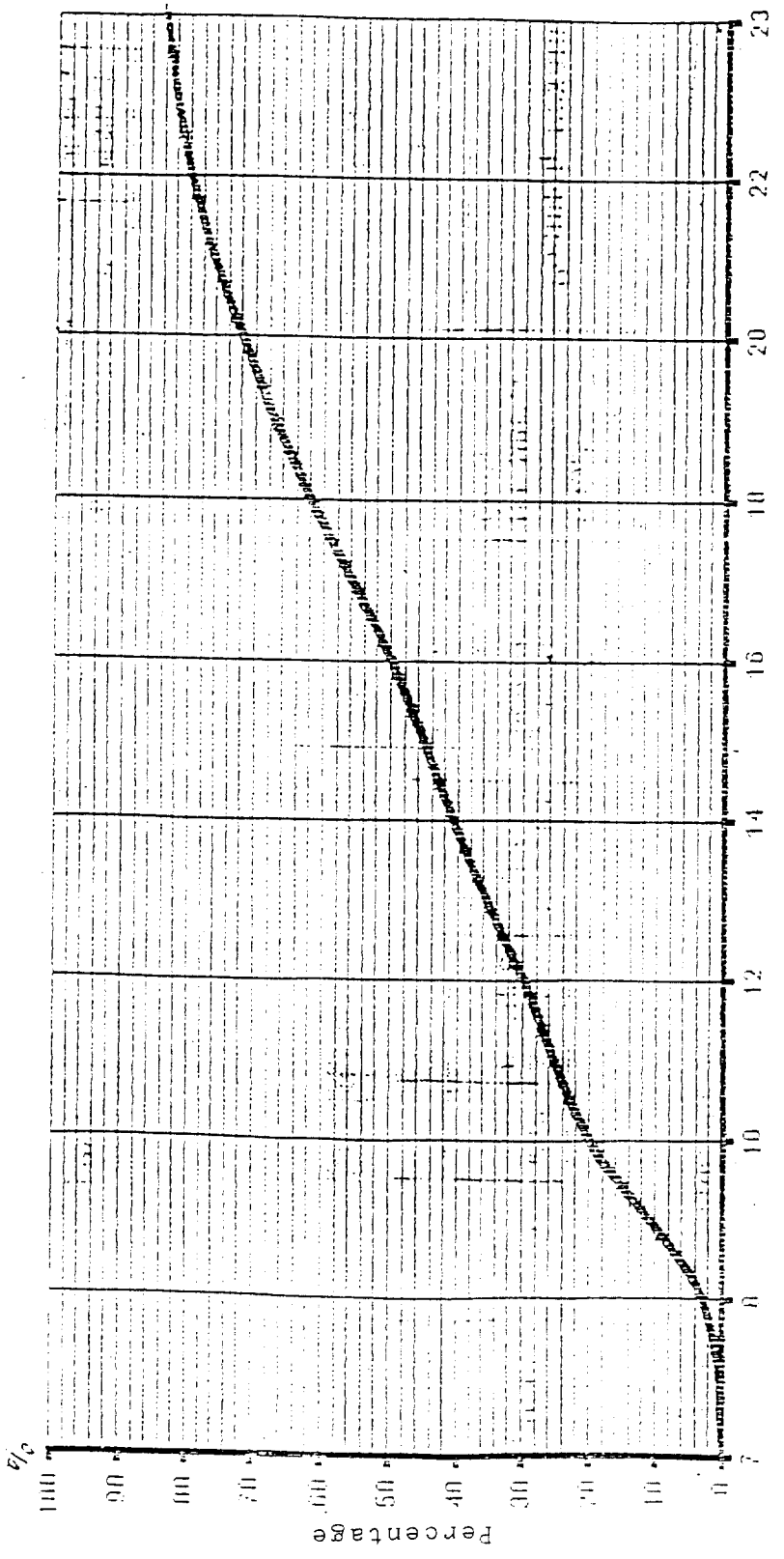
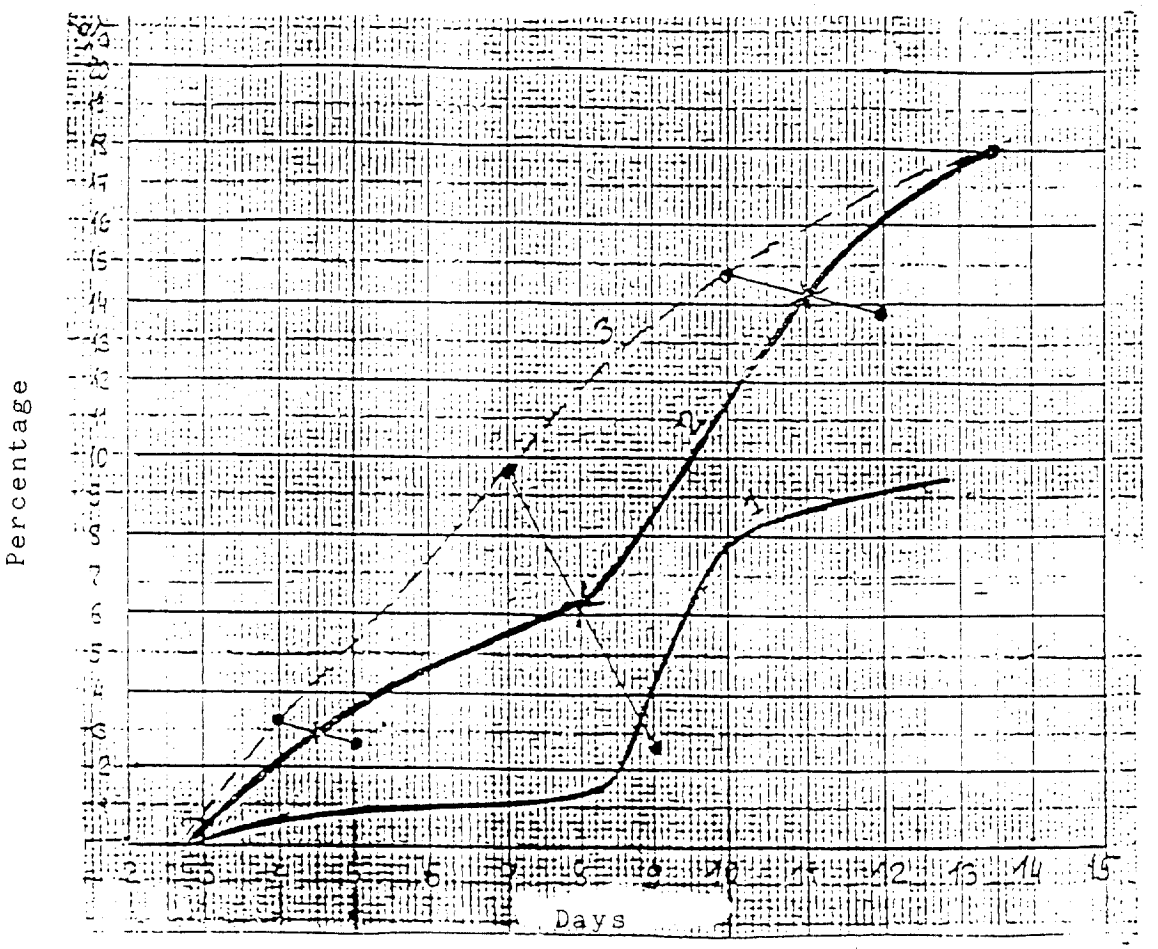

Increase in percentage of yellowed fruit in boxes
against time in wagon at temperature of 12-14° C
Percentage
Days in wagon

Fig. 3

Number of boxes containing yellowed fruit at end of journey: dependence on journey duration (from results of trial journeys)



I - Curve for average weighted percentage

2,3 - Curves for maximum percentages found against days travelled

• - Actual percentages

X - Theoretical point

Fig. 4

Table 1

MAXIMUM JOURNEY TIMES FOR CARRIAGE OF FRESH FRUITS,
VEGETABLES AND POTATOES, IN DAYS

Produce	April - June		July - August		September - October		November		Winter
	Refrigerated wagons	Covered wagons	Refrigerated wagons	Covered wagons	Refrigerated wagons	Covered wagons	Refrigerated wagons	Covered wagons	Refrigerated wagons
Apples:									
Early ripening	20	4	20	7	-	-	-	-	-
Late ripening for autumn sale	-	-	30	10	30	15	-	30	-
Late ripening for winter storage	-	-	-	-	20	15	20	15	20
Pears:									
Early ripening	12	3	12	5	-	-	-	-	-
Late ripening for autumn sale	-	-	15	8	18	10	30	30	-
Late ripening for winter storage	-	-	-	-	30	20	-	30	30
Quinces	-	-	-	-	30	30	30	30	30
Persimmons (unripe)	-	-	-	-	30	30	30	30	-
Plums, damsons	16	4	16	5	20	6	-	-	-
Peaches, apricots	12	-	15	-	16	-	-	-	-
Table grapes	15	-	18	-	20	8	15	-	15
Citrus fruits	30	-	30	-	30	-	30	-	30
Potatoes (for food):									
Early	14	6	15	8	-	-	-	-	-
Late	20	15	-	-	30	30	30	15	30
Water melons, thick-rind, in container	-	-	20	15	25	15	25	15	-
Cantaloupes, in container	15	7	15	10	20	10	15	-	10
Tomatoes:									
Pink	10	6	10	6	12	6	-	-	-
Brown	15	10	15	10	15	10	15	10	-
Milky	15	15	15	15	15	15	15	15	-

Table 2

Recommended temperature ranges and need for ventilation for refrigerated carriage of perishable produce

Produce	Temperature range		Need for ventilation
	From	To	
Chilled and unchilled potatoes, grapes, berries, late apples for winter storage, pears, mandarins, oranges, other fresh fruits and vegetables not listed below	+5	+2	Ventilation in event of heating; no ventilation in event of cooling
Pink and brown tomatoes, cucumbers, aubergines, sweet peppers, cantaloupes, pumpkins, pineapples, lemons	+9	+6	Ventilation in event of heating; no ventilation in event of cooling
Milky tomatoes	+13	+11	
Bananas	+13	+11	Ventilation in event both of heating and of cooling
Lemons	+9	+8	ditto
Mandarins, oranges, Star Ruby grapefruit	+8	+2	ditto
