TRANSPORT PROBLEM OF FRESH FRUIT AND VEGETABLES

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1 INTRODUCTION

This article is focused of the description conditions during transport, storage and ripening of fruit and vegetables. Main part will focus on describe the processes associated with the transport of bananas.

2 CONDITIONS OF TRANSPORT, STORAGE AND RIPENING OF FRUIT AND VEGETABLES

The transport of fresh fruit and vegetables is a complicated topic. Differing fruit and vegetables have widely varying requirements for their safe preservation. The rate at which living fruits and vegetables age and eventually submit to senescence, attack by micro-organisms and inevitable demise depends upon the environmental status afforded during storage and transit. The most important factor that must be observed to maintain the temperature of transported goods at an optimal level. For safe carriage this will usually require that the commodities are pre-cooled and maintained at that temperature prior to being loaded into the transport unit, be it refrigerated ship, container or other mode of transport. It must be maintained throughout the period of shipment unchanging the optimum temperature in a transport unit with respect to the type of goods transported. Every kind of fruit and vegetables require different temperature.

All fresh fruits and vegetables are living products and their life processes continue after harvest; the two most important being respiration and transpiration. The normal respiration results in the fruit and vegetables consuming oxygen and giving off carbon dioxide; water; and varying, albeit immense, amounts of heat. The higher the ambient temperature surrounding the commodity the greater will be the temperature of the commodity itself and consequently the larger its rate of respiration. The second process, transpiration, is the loss of water by evaporation which will occur once the fruit or vegetable is removed from its tree or plant which has been the source of water
during its formative period. Thus the storage/carriage conditions afforded the produce should be such that excessive water loss does not ensue.

2.1 Temperature

Many reference books include tables which provide data, including optimum temperatures, for the safe storage of commodities. Other publications specifically list the optimum transit (carriage) conditions. Published data applicable to sea-going carriage requirements may indicate slightly higher optimum temperatures. However it is essential to understand that published values of optimum temperatures for storage or transit are not absolute – the accurate optimal requirements are dependent upon varietal, climatic and other details of the produce. The optimum and required transport temperature of fruits and vegetables should be provided in writing by the shipper who will, or should, have full knowledge of the history of the produce and which temperature must be maintained by the carrier throughout the period under his control. Generally speaking the higher the temperature the faster will be the growth of moulds and bacterial infections.

2.2 Freezing points

The lowest safe limit of temperature for each commodity is its highest freezing point. This temperature is invariably slightly below 0°C Generally speaking the main contents being sugars the sweeter the produce the lower the freezing point. Nonetheless it must also be remembered that stalks of fruit contain much less sugar and may freeze at a higher temperature than the fruit itself, resulting in death of the stalk tissue with possible consequences when the fruit is restored to ambient temperatures with likely loss of sound market values.

2.3 Chill damage

A second factor which establishes the lower safe limit of carriage temperature of some produce is that of chilling, which is a reduction in temperature that does not reach the freezing point of the produce. Numerous commodities especially those grown in tropical climates, or alternatively from plants originating from the tropics, are easily affected by low temperatures and inclined to injury to their tissues at temperatures well above their freezing point.

2.4 Relative humidity

Relative humidity may be defined as the ratio of the water vapour pressure present in air at an existing temperature to the water-vapour pressure which would be present if the vapour were saturated at the same temperature.
Thus the relative humidity of the air within a cargo compartment of a refrigerated vessel, insulated refrigerator container or trailer directly determines the retention of the condition of the products carried. Relative humidity below the optimum range will result in shrivelling or wilting in most produce. The maintenance of an optimum range of humidity is often one of the more difficult to resolve during the carriage of fresh produce.

Relative humidity of air of 85% to 95% is usually recommended for the carriage of most perishable produce in order to preclude/impede wilting or shrivel caused by moisture loss. Exceptions to the above include the carriage of onions, dates, coconuts, ginger rhizomes, yams, dried fruits and some horticultural produce. If the relative humidity increases to 100% condensation may occur which would increase the likelihood of mould growth within the compartment and on the produce itself.

2.5 Air circulation

The circulation of cooling air within cargo compartments must be kept at an even required temperature throughout. Despite variable heat leakages which may occur in various parts of the system, and the inevitable increase in the circulating air temperature at return compared with delivery, the result of removal of respiratory heat from the produce, only a small increase should be acceptable. As the majority of produce carried should be presented to the vessel/container or trailer as precooled. The circulating cooling air should therefore only be required to remove respiratory heat of the produce and the heat exchanged via exterior surfaces. A high velocity of circulating air should be unnecessary and in fact undesirable. Cooling air in modern refrigerated vessels and containers is usually circulated vertically, from the deck/floor, upwards. The system is designed to produce equal air pressures over the full area of the cargo space. However, any elaborate arrangement for air distribution can be rendered useless if incorrect stowage of the produce eliminates or reduces efficient airflow which tends to follow the route of least resistance. The difficulties of ‘properly and carefully’ stowing packages of fresh produce have become more complex with the use of palletised units and pallet boxes/bins.

2.6 Air exchange

During the carriage of fresh fruits and vegetables under ordinary conditions of refrigeration accumulations of gases such as carbon dioxide (CO2) and ethylene (C2H4) will occur. Undesirable odours or volatiles may also contribute to off-flavours and hasten deterioration of the produce. These problems can be prevented by repeatedly refreshing the circulating air within the holds by admitting atmospheric air into the system. The introduced air entering at a point of lowest pressure within the
circulation and the polluted air exiting the system at a point of highest pressure, or alternatively by use of an auxiliary air system driven by separate fans.

2.7 Climacteric fruit and vegetables

The climacteric is a stage of fruit ripening associated with increased ethylene production and a rise in cellular respiration. Some varieties of fruit and vegetables have rates of respiration which do not decline during their ripening period – that is between maturation and the onset of senescence. Many fruits are climacteric, such as peach, apricot, banana, mango, papaya, avocado, plum, tomato and guava and tend to ripen rapidly during transit and storage. Examples of non-climacteric fruit and vegetables include cucumber, grape, lemon, lime, orange, temple fruit (satsuma, tangerine, mandarin) and strawberry.

2.8 Weight loss in transit

Weight loss from harvested produce can be a major cause of deterioration during transit and storage. Most fruit and vegetables contain between 80% and 95% of water by weight, some of which may be lost by transpiration (water loss from living tissue). To minimise loss of saleable produce weight and to preclude wilting and shrivelling, the produce must be maintained during transit at the recommended humidity and temperature. Whereas some weight loss will inevitably occur due to the loss of carbon during respiration, this will only be of relative minor proportions.

2.9 Supplements to refrigeration

Opportunities have been tried and tested to slow down ripening after harvest and thus extend the transit, storage and shelf life of fruit and vegetables – especially those in the climacteric category. This can be achieved with controlled atmosphere (CA) storage and carriage; modified atmosphere packaging (MAP), storage and carriage (MA); or alternatively with edible coatings.

Basically and in all cases the atmosphere created is one of low oxygen (O2) and high carbon dioxide (CO2 ) when compared to atmospheric air. The low oxygen and high level of CO2 depress the production of ethylene (C2 H4), a gas emitted in small quantities by plant tissues, which accelerates during the ripening process and in turn expedites the process itself in the form of a chain reaction, especially true in the case of bananas.

2.10 Carriage of mixed produce

At times carriers are required to load and stow different produce in the same vessel, hold, or cargo container. Should a mixture be necessary it is essential that the produce is compatible in respect of:
• Temperature
• Relative humidity
• Odour production
• Ethylene production.

Cross tainting should be avoided at all costs whereby strongly scented fruit and vegetables are stowed together. The many products which produce considerable ethylene naturally, including apples, avocados, bananas, pears, peaches, plums, melons and pineapples should not be stowed with or in adjacent compartments to kiwi fruit, water melons, lettuce, carrots etc. which can all be seriously affected by the ethylene.

One of the most commonly transported fruits are bananas. To carry this type of fruit is mainly used for road and maritime transport. Means of transport as containers, road trailers and boats. The article will be describe packaging, mode of transport and ripening of this type of fruits, because it is specify commodity.

3 Package, carriage and ripening of bananas

Banana is the most important perishable commodity in international trade. Cargoes of bananas are carried either in the holds of reefer (refrigerated) vessels or in refrigerated shipping containers, and a voyage may take a few days or several weeks. The period between harvesting of bananas and initiation of normal ripening, i.e., the duration of the pre-climacteric phase, is sometimes called ‘green-life’. The international banana trade is based on the harvesting and transportation of hard, green, unripe fruit, which is later ripened in the country of consumption. The aim of refrigerated carriage of bananas is to deliver fruit that is still in the preclimacteric state, so that the climacteric may subsequently be artificially induced, in a uniform and controlled manner, by injection of a measured quantity of manufactured ethylene into the commercial ripening room. In this way it is feasible, within limits, to release ripened fruit on to the market according to demand.

Most cargoes arrive in good condition, but occasionally some of the fruit ripens prematurely aboard ship, or suffers chilling injury, resulting in substantial losses and protracted litigation.

3.1 Preshipment factors

Fruit characteristics may be influenced by temperature, rainfall, cloud cover and so forth. These factors also determine the likelihood of disease.

Bananas must be cut at a maturity that will allow them, under normal transport conditions, to arrive at their destination (i.e., in the ripening room) before ripening has
commenced. The appropriate maturity stage for cutting depends partly on the cultivar of banana and partly on the duration of the proposed journey. Fruit intended for distant destinations must be cut while relatively thin, whereas fruit destined for a short voyage can develop to a slightly fuller grade before being harvested.

**Fig. 1 Fruit after harvest**

![Fruit after harvest](source [3])

### 3.2 Postharvest handling and packing

It is essential to handle fruit carefully in order to minimize damage (cuts and bruises), the effects of which will be manifest when the fruit ripens. Injury results in increased rates of respiration, and also predisposes the fruit to fungal attack.

The current method of packaging for bananas consists of a polyethylene bag within a sturdy, ventilated, cardboard carton. The clusters (part hands) of bananas are carefully placed in four rows, the two upper and the two lower rows separated by a flexible cardboard pad designed to prevent fruit-on-fruit injury. The pad is outside the bag, but projects between the rows via a fold in the bag. Thin polyfilm is used in the standard ‘Polypack’ and, besides reducing abrasion, minimizes fruit moisture loss. Moisture loss is undesirable because of the concomitant weight loss, and also because water-stressed fruit tends to ripen prematurely. Thicker polyfilm can be used to create a modified atmosphere (MA) around the fruit. In the ‘Banavac’ system, the polyethylene bag is partially evacuated before being tightly sealed at the neck.

This procedure permits rapid establishment of an appropriate atmosphere and reduces the risk of over-modification and resultant suffocation. ‘Polypack’ packaging cannot be relied on for a period greater than about 28 days, while ‘Banavac’ has been known to maintain green-life for as long as 40 or even 50 days, so is advantageous in the event of delay. While useful as a means of extending storage life, MA packaging carries one disadvantage: the polyethylene bag must be punctured before arrival in the ripening room (to facilitate ingress of ethylene gas), and this involves costly labor. Superior to MA is controlled atmosphere (CA), in which appropriate concentrations of
oxygen and carbon dioxide are accurately maintained within the hold space (by special apparatus), rather than approximately maintained within each package (by means of the fruit’s own respiration). For CA carriage, bananas must be packed in 'Polypack'. The cartons are provided with perforations to ensure a proper flow of cooling air around the bananas. The side faces each have four oblong perforations of 1.5 cm x 6 cm and the end faces each have a handle-type opening of 3.5 cm x 10 cm and a further two holes 3.5 cm in diameter.

![Fig. 2 Type of boxes](image)

In the box is saved in the 4 rows above each other, always two and two separate cartons. Shipment to the recipient shall be made in reefer maintaining the desired temperature.

Furthermore, these cartons stored on a pallet, which is on one pallet together 48 cartons (8 layers of 6 cartons in a single layer). Is used to transport non-returnable pallet with dimensions 1000 x 1200 mm. One box of bananas weighs about 20 kg in total, so one pallet has a gross weight of about 985 kg. Cartons on a pallet has been locked from the side edge of the cardboard and polypropylene tape.

Bananas should be stowed in refrigerated space preferably within 24 hours, certainly within 48 hours, of harvest; a common stipulation is that a period of 36 hours should not be exceeded. If bananas remain at high ambient temperature for longer than this, their green-life will be curtailed. Factors influencing the initiation of ripening include cultivar, growing conditions, age and grade at harvest, storage temperature and humidity after harvest, and the presence or absence of ethylene in the atmosphere. The following examples illustrate the time scales involved.

Since the onset of ripening is characterized by an increase in respiration (the climacteric rise), and since respiration involves the evolution of heat, the first obvious indication that ripening has begun may well be the increase in pulp temperature of the fruit. This is the reason for temperature checks at the time of loading; pulp temperatures above 32°C give cause for concern, and ‘hot fruit’, if detected, will be
refused for loading. If ripening fruit is inadvertently loaded it will complete the ripening process during the first few days of the voyage, and by the time of discharge, is likely to have become overripe, brown or black, even moldy and collapsed, depending on its initial state coupled with the environment and duration of the journey.

3.3 Carriage instructions

In road vehicles carrying bananas from the plantations to the port are handled using a pallet truck. For ships to which pallets loaded with bananas directly into the cell ships are loaded by crane located on the ship. Unloading port in Europe is conducted so that the palette of cells loaded on a ship deck, where workers loaded them in a cell using a pallet truck. Containers are unloaded from a ship using riverside gantry crane, or by crane located directly on the boat.

Shippers’ carriage instructions must take into account the cultivar, the weather during the growing season, the maturity of the fruit at harvest, and the expected duration of the voyage. Most usually, the recommended delivery air temperature (DAT) for bananas is in the region of 13.3°C.

![Refrigeration container](source[6])

3.4 Shipboard factors

**Refrigerating power**

The refrigerating plant must cool the warm fruit and also dissipate the heat produced by continuous respiration of the bananas. The heat output of pre-climacteric bananas at different temperatures is given in round figures in Table 1. Once bananas have entered the climacteric phase their respiratory heat output may be three, four or even five times the quoted figures.
Air circulation system

The first reefer vessels built specifically to carry bananas were generally designed with a horizontal airflow because at that time bananas were transported ‘on the stem’, and such an airflow permitted effective air circulation through the bunches. With the advent of carton-packing in the 1960s, it became more appropriate to have a vertical system, the usual method being powerful underdeck air delivery and deckhead exhaust to force air upwards through the cargo.

Stowage

In vessels with a powerful vertical airflow, a ‘solid stow’, without specific air channels, is essential. Because the resistance of a tightly packed stack of cartons is much greater than that of the loosely stowed bunches of earlier times, it is important to take care when constructing a stow of cartons. They should be stowed in register, so that air can flow through the interstices between the cartons. Cartons should also be stowed as level as possible, so that airflow will be uniform. Furthermore, it is necessary to leave sufficient headspace above the stow for the passage of the return air. If cartons are palletized, it is even more important to take care with stowage, since air tends to take the line of least resistance through the spaces between the pallet loads [7-9].

Fig. 4 Special ship for transporting bananas

Ripening

The banana ripening process has several parts. The first part is on the plant (separated from plant), the second part is hormone controlled (with ethylene), third part is conversation starch to sugar and fourth part is process „from green to yellow“. In transport unit are green bananas and after unloading in recipient start second part of ripening proces. Four major factors used of ethylene gas, temperature control, relative humidity control and adequate air circulation. In ripening rooms used ethylene gas. This process is usually performed in specially ripening room. Banana fruits are exposed to the gas for about 24 hours. The room must be ari tight, adequate
refrigeration, air circulated. The boxes of bananas should be „air stacked“. That is, the boxes should have air to circulate among all the boxes.

Fig. 5 Ripening process of bananas

There are the most commonly ripening systems:

Fig. 5 Tarp

Fig. 6 Air bags (vertical air circulation)
The ripening bananas is at the requirements of the final customer. Last shipment must be carried out under strict conditions. Observed to be the optimum temperature as well as during transport from the grower to the storer [8,9].

References

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Resume

The most important factors in the transport of fruit and vegetables is proper storage of goods prior to shipment, maintenance of correct temperature throughout the period of transport. It is essential for the proper ripening of goods in the hold to maintain proper relative humidity, provide ventilation and extraction and air supply. One of the most frequently transported fruits are bananas. These are specific because they are harvested as green and during transport is the minimum allowable ripening process. This is the most common transport up and running in chambers. Ripening takes place in strict compliance with the conditions, especially temperature, amount of substance and maturing fruit that spends time in the chamber.

Key words

Fruit, bananas, ripening

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