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International Standard



931

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## Green Bananas — Guide to storage and transport

*Bananes vertes — Guide pour l'entreposage et le transport*

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 931 was developed by Technical Committee ISO/TC 34, *Agricultural food products*.

It was submitted directly to the ISO Council, in accordance with clause 5.10.1 of part 1 of the Directives for the technical work of ISO. It cancels and replaces ISO Recommendation R 931-1969, which had been approved by the member bodies of the following countries :

Australia	India	Portugal
Bulgaria	Iran	Romania
Colombia	Israel	Thailand
Czechoslovakia	Korea, Rep. of	United Kingdom
Egypt, Arab Rep of	Netherlands	USSR
France	New Zealand	Yugoslavia
Greece	Norway	
Hungary	Poland	

No member body had expressed disapproval of the document.

# Green bananas — Guide to storage and transport

## 0 Introduction

Bananas should be stored, before transport from the exporting country to the place of consumption and throughout the period of transport, in the green condition and, therefore in the preclimacteric phase.

A banana is said to be in the preclimacteric phase when the process of ripening has not yet been initiated.

Harvesting of bananas takes place throughout the year in tropical and sub-tropical regions having considerable variations of an ecological and climatic kind. It follows that the state of dimensional development (fullness) of the banana does not afford a precise criterion of its degree of ripeness. A thin banana (in a period of drought) may be in an advanced degree of ripeness.

Moreover, the degree of ripeness to be chosen depends on the duration of transport, which varies considerably (from a few days to 3 weeks).

The producer should time the cutting of the bananas so that the degree of ripeness (as estimated from their fullness) is compatible with the transport envisaged. The time of cutting therefore depends on two distinct factors: the duration of refrigerated transport and the physiological state of the banana. For this reason the recommendations for the degree of ripeness (see 2.1) cannot be universally applicable and can be only of a general nature which serve as a pointer to the producer, who has to decide on his own criteria for cutting.

As regards examination for ripeness, a bunch of bananas may be likened to a bunch of grapes with fruit in different states of ripeness, and it is therefore essential to specify with what fruit the check is to be carried out.

The state of the bananas (state of health, wounds, etc.), when they enter the store, has an influence on the storage life, and this is the justification for making recommendations on this subject.

The same applies to the precautions to be taken between harvesting the bananas and putting them into the store. The high temperature of the producing areas and exposure to sunlight can appreciably reduce the storage life.

The term *cultivar* is used to indicate that the varieties of bananas entering into commerce are cultivated varieties.

Anti-fungal treatments of the ends of the main stalk or ends of

the cushions have not been mentioned, because it is not possible to indicate treatments which are recognized beyond dispute.

## 1 Scope and field of application

This International Standard describes conditions for the successful keeping, with or without artificial cooling, of green bananas, *Musa* sp., in the preclimacteric phase during storage before transport from the place of production to the place of consumption and during maritime transport.

## 2 Conditions of harvesting and putting into store

### 2.1 Harvesting

The degree of ripeness of the banana at harvesting should be determined as a function of its firmness and the number of days elapsing between harvesting and putting into the ripening room. It should not be too advanced, in order that the bananas may remain in the preclimacteric phase until they are put into the ripening room in normal conditions of transport.

#### 2.1.1 Criteria of ripeness

The criteria of ripeness most generally used in practice are:

- the fullness, which is a dimensional criterion;
- the colour of the flesh, which is a criterion of the physiological state and is assessed by means of a conventional colour scale enabling a numerical value to be obtained;
- the firmness of the flesh, which is a criterion of the physiological state and is measured by means of a spring penetrometer (with a cylindrical end 4 mm in diameter, and a spring which is reduced in length by 100 mm under a force of 24,5 N);
- the characteristic odour of the flesh of the banana in the preclimacteric phase.

These criteria are not universally valid and, for each cultivar grown in the same way, they can vary from one region to another, and the producer should decide on his own criteria for cutting.

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**2.1.2 Examination for degree of ripeness**

Examination for the degree of ripeness of a bunch of bananas should be carried out by using the representative fruit found in that part of the bunch which is in the most advanced state of ripeness, i.e. in the first or second hand reckoned from the largest end of the main stalk. The representative fruit is the centre fruit of normal shape in the inside row of the first or second hand. The degrees of ripeness of the fruits of the first and second hand can be considered as equal.

**2.2 Quality characteristics for storage and transport**

The bananas should be free from signs of attack by fungi, bacteria, insects or animal pests, and should be free from parasites. They should not be injured by fungal or physiological diseases.

In order to avoid the development of fungal diseases during storage, the fruit should be clean. It should not be stained with sap and the fruit stalks should be intact. The main stalk of the bunches should not show marks of sunburn and its two sections should be fresh, clean, and without smears, tears or breaks.

The bananas should be free from evident marks of rubbing, scraping, bruising or sunburn.

Removal of the pistils should be carried out in those producing areas where the climate and conditions of cultivation favour the development of rot. It should be carried out on the tree itself if the size of the banana tree allows this.

**2.3 Putting into store**

The bananas should be put into cold store for long journeys, or into ventilated store for short journeys, as soon as possible after harvesting. The interval between cutting the bunch and putting it into a refrigerated or ventilated enclosure (pre-refrigeration room, storage room or ship's hold) should be less than 24 h if possible, and should not in any case exceed 48 h.

After harvesting and packaging, if the bananas are awaiting land transport to the port of embarkation, they should be put in the shade and in a well ventilated place.

At the port of embarkation, the waiting time of lorries or wagons loaded with bananas, before transfer to the ship's holds, should be reduced to the minimum and the vehicles should be in the shade.

**2.4 Method of storage**

Green bananas should be stored :

- in hands or portions of hands (clusters) in cartons;

- in bunches, in bags of perforated polyethylene;

- in bunches, enclosed in a protective mattress which allows gas exchange and has a thermal conductance sufficient to ensure satisfactory cooling (straw, paper, etc.);

- in uncovered bunches, arranged in bulk. This method of storage should be carried out with very great care in order to avoid damaging the bananas, which would lead to deterioration during transport and ripening.

**3 Optimum storage and transport conditions (with artificial cooling)**

Refrigerated storage and transport of green bananas comprises two phases : cooling and storage.

**3.1 Cooling****3.1.1 Rate of cooling**

Cooling of the bananas should be carried out as rapidly as possible. It depends on the following factors :

- the power of the refrigeration plant (of the order of 700 to 800 calories per hour per tonne of bananas). With a central refrigeration plant, and loading of the banana vessel divided between two days, it is possible to apply the whole of the refrigerating power of the vessel to the first half of the cargo from the start of refrigeration and to dispose of more than 1 000 calories per hour per tonne of bananas;

- the air circulation ratio<sup>1)</sup> in each ventilation section;

- the uniformity and speed of the air circulation across the load;

- the surface of each package in contact with the cooling air;

- the efficiency of ventilation (effect of external and internal short-circuits of the air);

- the mode of packaging (polyethylene wrappers or cardboard boxes of different kinds);

- the method of storage (compact or in stacks);

- the method of loading the banana vessel (continuously or in 2 days with an interval of 12 h at night).

<sup>1)</sup> *Air-circulation ratio* is defined as the ratio of the volume of air passed in 1 h by the fans to the volume of the empty chamber.

### 3.1.2 Temperature

The temperature of the bananas is lowered from 25 to 30 °C, which is that of the bananas on loading into the ship's holds, to the practical storage temperature (see 3.2.1).

### 3.1.3 Relative humidity

The relative humidity of the air at the delivery side varies whilst the bananas are being cooled because the working range of the cold batteries is not stable. It increases at the end of cooling, when it should lie between 85 and 90 % at the entry of the delivered air into the banana compartments.

### 3.1.4 Air circulation

An *air circulation ratio* of 80 to 100 per ventilation section (collection of compartments, usually two, depending on the same fan or fans) is recommended.

The ventilation system recommended is that with vertically ascending or descending air in series (two compartments superimposed and separate by a slatted floor), with a uniform distribution of air over the surface at the suction side or the delivery side. Each compartment is traversed by all the air delivered by the fans and consequently its air circulation coefficient is double that of the ventilation section.

The rate of air change<sup>1)</sup> recommended is one change per hour, but it may be reduced to half a change per hour during cooling in order not to retard this.

## 3.2 Storage

### 3.2.1 Temperature

Throughout the period of maritime transport, after cooling of the bananas, it is necessary to ensure that the practical storage temperature of the delivery air is maintained at the value adopted. This is achieved by adding to the critical storage temperature (the temperature which induces damage to the bananas due to cold) a safety margin sufficient to take account of unavoidable temperature fluctuations arising from the refrigeration plant and its operation (+ 0,2 to + 0,5 °C for a refrigeration plant using brine; + 0,5 to + 0,7 °C for a direct expansion plant).

The critical temperature for bananas is not constant, its value depending on the cultivar considered, on the degree of maturity of the crop, its sanitary state, and the duration of the maritime transport.

The following values are given as indications only :

Cultivar	Period of storage days	Critical temperature <sup>2)</sup> °C
Gros Michel	12	12
Lacatan	11 to 13	14,4
Poyo (Robusta)	14	12
Grande naine (Giant Governor)	14	12
Petite naine (Dwarf Cavendish)	16	12

### 3.2.2 Relative humidity

The surface of the air coolers should be designed so that a relative humidity of 85 to 90 % is obtained at the cold point of the refrigerated enclosure in the stabilization period when the cooling of the bananas is completed.

### 3.2.3 Air circulation

During storage, the air circulation ratio may be reduced to half after the end of the cooling period.

The recommended rate of air change is one change per hour.

### 3.2.4 Ripening

Ripening of the bananas during storage should be avoided by all possible means. Ripening is accompanied by an increase in the production of carbon dioxide and by the production of ethylene, which is liable to trigger the ripening of the adjacent bananas.

Experience in storage shows that with an efficient ventilation system, ensuring continuous sweeping of all parts of the load by the air circulating in the holds of banana vessel, and with continuous changes of fresh air, carbon dioxide and ethylene can be removed without any action on the adjacent fruit.

The occurrence of an abnormal percentage of ripe bananas on discharge of the banana vessel arises from four causes which should be avoided :

- keeping at ambient temperature at the port of arrival;
- loading of bananas at too advanced a stage of ripeness;
- defects in ventilation;
- defects in the refrigeration plant.

1) The *rate of air change* is the ratio of the volume of outside air introduced into the refrigerated enclosure in 1 h to the volume of the empty enclosure.

2) *Critical temperature* is the temperature from or below which, for a given period of storage, physiological disorders are produced or it is not possible to obtain normal ripening when the product is taken out of storage.