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FRuiTROP

English edition

The international banana market: from one world to the other

The reefer revolution and its impact on the banana trade

Fruit conservation and quality: ripening

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Fruit conservation and quality

Ripening

The world of fruit is complicated! For botanists, a fruit is a plant organ containing a seed and so a pea pod is a fruit, as is a peach. For consumers, the word fruit immediately brings to mind a coloured, sweet fruit. But nature provides us with vast diversity—from chestnuts to blackberries, from strawberries to grapefruit. There are dry fruits, fleshy fruits, compound fruits (pineapple and figs), berries (melons, passion fruit, tomatoes), drupes (apples, mangoes and peaches), multiple fruits (blackberries and raspberries), complex fruits (strawberries), etc. Beyond this terminology that belongs to the world of specialists, the important thing for consumers is to have access to this range of forms, tastes and colours. Here, FruiTrop is starting a new series of articles on fruits conservation and quality.

It is interesting to note that most fruits, whatever the species, display the same features in ripening, such as changes in colour, texture, flavour and the formation of aromas. Fruits become attractive so that they are eaten. The changes on the plant or the tree take fruits to full maturity, as the prime objective is the dissemination of the seeds.

The postharvest paradox

The sensorial (flavour and aroma), energy (mainly carbohydrate), and nutritional (micronutrients) features (micronutrients) are at their best in ripe fruits only. But the simple problem of how to achieve a sufficiently long storage period arises when they are to be sold on the market. Should they be picked before they are completely ripe? Reconciling storage time and quality is a compromise and difficult in practice as fruits do not all ripen in the same way. Very schematically, the fruits that ripen gradually are referred to as 'non-climacteric' and those that ripen suddenly are 'climacteric'.

Non-climacteric fruits

After growth, some fruits such as grapes, cherries and citrus ripen gradually on the plant and develop optimum attractiveness. The rate of ageing determines the possible duration of survival on the plant—ranging from a few days to several weeks, depending on the species. Harvesting is generally performed on the basis of external signs of ripeness, such as change of colour, texture, etc. The characteristics of the fruit when picked will be practically the same as when they reach the consumer as long as conditions of release on the market are respected: time elapsing between picking and distribution, storage and transport conditions, etc.

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A few examples of climacteric and non-climacteric fruits	
Climacteric	**Non-climacteric**
Apricot Sugar apple Avocado Banana Carambola Guava Granadilla Kaki Kiwi Mango Papaya Peach Pear Apple Plum	Citrus fruits Pineapple Cherry Pomegranate Litchi Grape Tamarillo

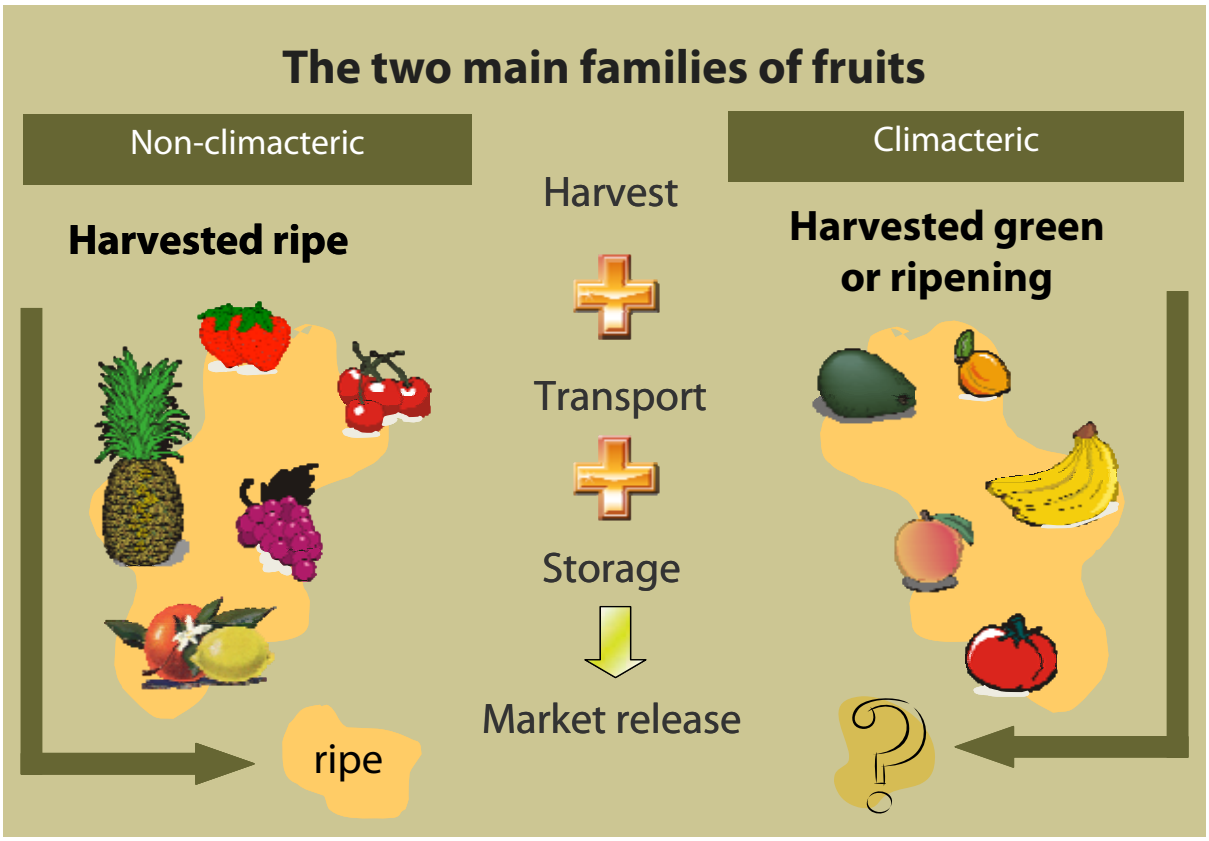
Climacteric fruits

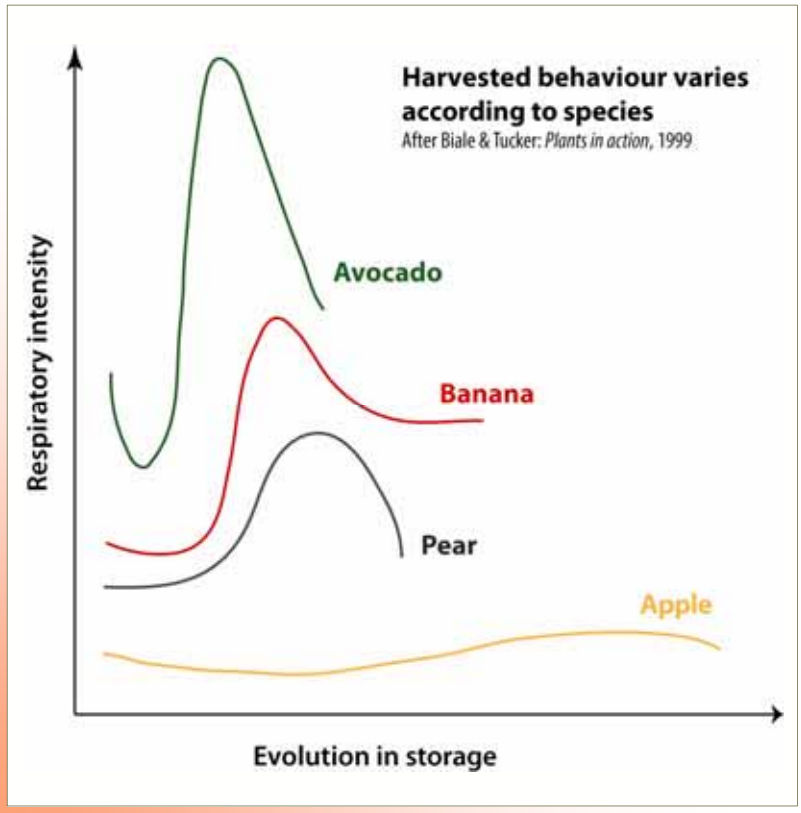
Other fruits such as bananas, mangoes and avocados ripen suddenly and change in a few days. As a result, if transport time exceeds that of the conservation period of ripe fruits, there is no question of waiting for the fruits to start ripening before harvesting them. They must be picked earlier than this. So what is the relation between the characteristics of fruits that are still unripe and those of the same fruits once that they have ripened?

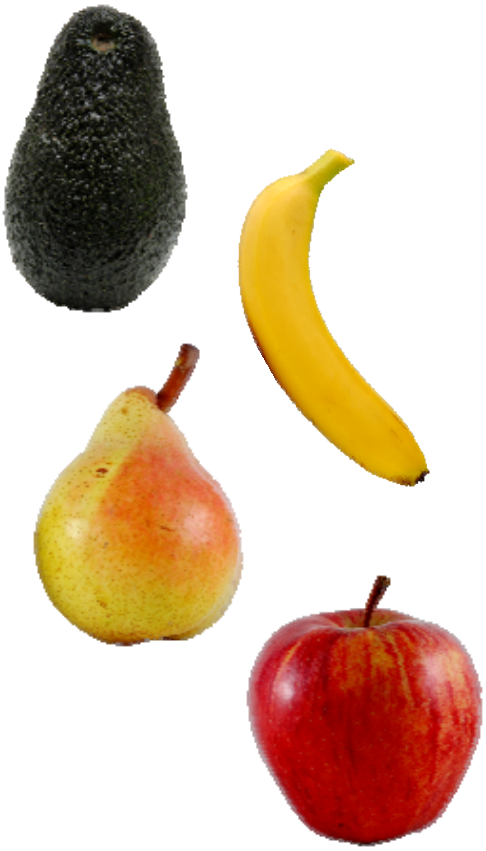
Different metabolisms

Talking in terms of the 'sudden' ripening of climacteric fruits is sometimes justified and sometimes excessive. Indeed, the rate of start of ripening is not a constant and depends on the fruit species. A laboratory technique for the comparison of rates of start of ripening consists of measuring respiration intensity. Like every living organism, fruits use oxygen to provide the energy that they require for growth or survival. As there is, in parallel, release of carbon dioxide, this O2-CO2 exchange is considered as respiration and therefore provides some information about the metabolism of the fruit. For example, the respiration intensity of fruits is temperature-related. It increases at high temperature and fruits become senescent more rapidly, and decreases when the temperature falls as the rate of senescence is slowed.

Respiration intensity increases distinctly during the 'climacteric', when a climacteric fruit starts to ripen. The intensity and duration of the climacteric vary according to the species, but the pattern is always a wave that may be more or less





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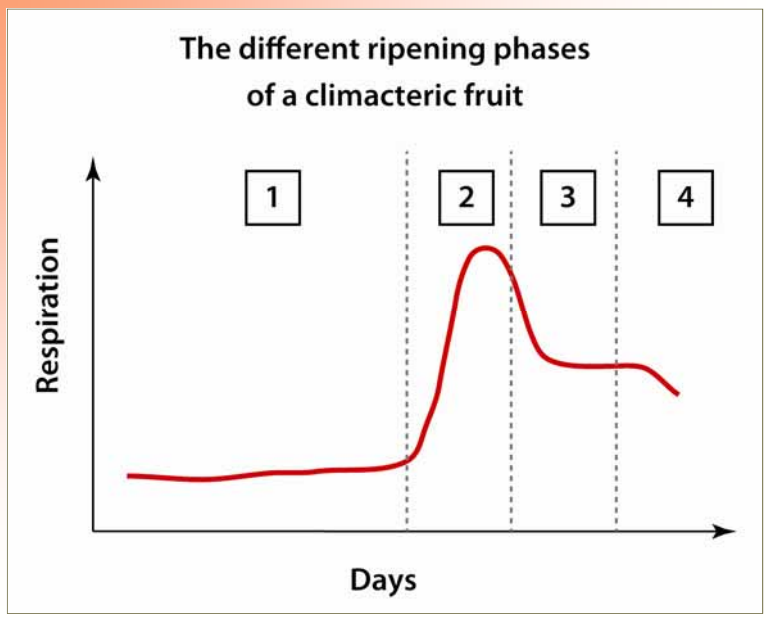
marked. In contrast, the graph of the respiration of non-climacteric and non-senescent fruits is always a straight line.

Reference to the ethylene status is often made in differentiation between climacteric and non-climacteric fruits. While ethylene is known as a gas (a hydrocarbon), it is also a hormone that is synthesised naturally in plant products and is closely involved in the physiology of plants. It is also known as a ripening and senescence hormone.

When non-climacteric fruits are exposed to ethylene their respiration intensity increases temporarily. When they are returned to an ethylene-free environment, they recover their original respiration rate, showing that ethylene does not have a marked impact on their metabolism.

Climacteric fruits react when exposed to ethylene and their respiration intensity increases. This feature remains when they are returned to ethylene-free conditions as they have started to ripen. 'Exogenous' ethylene thus triggers the ripening of climacteric fruits. This feature is used expertly for bananas in the management of market releases.



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Ripeness

A ripe fruit is one whose seeds are fully developed and is ready to be picked. There is no ambiguity here for non-climacteric fruits. But can climacteric fruits be picked when not fully ripe? They are at a stage of ripeness at which they can be picked but are not ripe for eating. The term 'full mature green' is the most appropriate definition.

The ripening of non-climacteric fruits is often associated with a change in colour (veraison in grapes, loss of chlorophyll in pineapples, etc.). Ripening of climacteric fruits depends on the start of the climacteric. The curves above can therefore be categorised in four successive phases consisting of the following phases:

1. **pre-climacteric:** the fruit is green;
2. **climacteric:** the fruit starts to ripen;
3. **post-climacteric:** the fruit is ripe for consumption;
4. **senescence:** end of ripeness for consumption; the fruit deteriorates.

An untruth: climacteric fruits must be picked green to be able to ripen

It is sometimes stated that a climacteric fruit must be picked green and then allowed to ripen. This deserves a few comments.

Most climacteric fruits ripen very well on the plant. Eating apricots, peaches, nectarines, apples or plums chosen on the tree at the peak of the season is a great pleasure. They are truly ripe! However, fruits left on the plant continue to take up nutrients. In some cases they fill until they burst. This is the case of banana, for example. The peel of fruits on bunches left to ripen on the plant may split. Most avocados are excellent when picked ripe, but the fruit is often described as being unsuitable for ripening on the trees. Chilling is necessary or recommended for the good ripening of some temperate fruits. This is the case of 'Granny Smith' apple and 'Passe Crassane' pear, late varieties that would benefit from cold weather when still on the trees. When these fruits are picked at harvest ripeness rather than consumption ripeness, cold conditions

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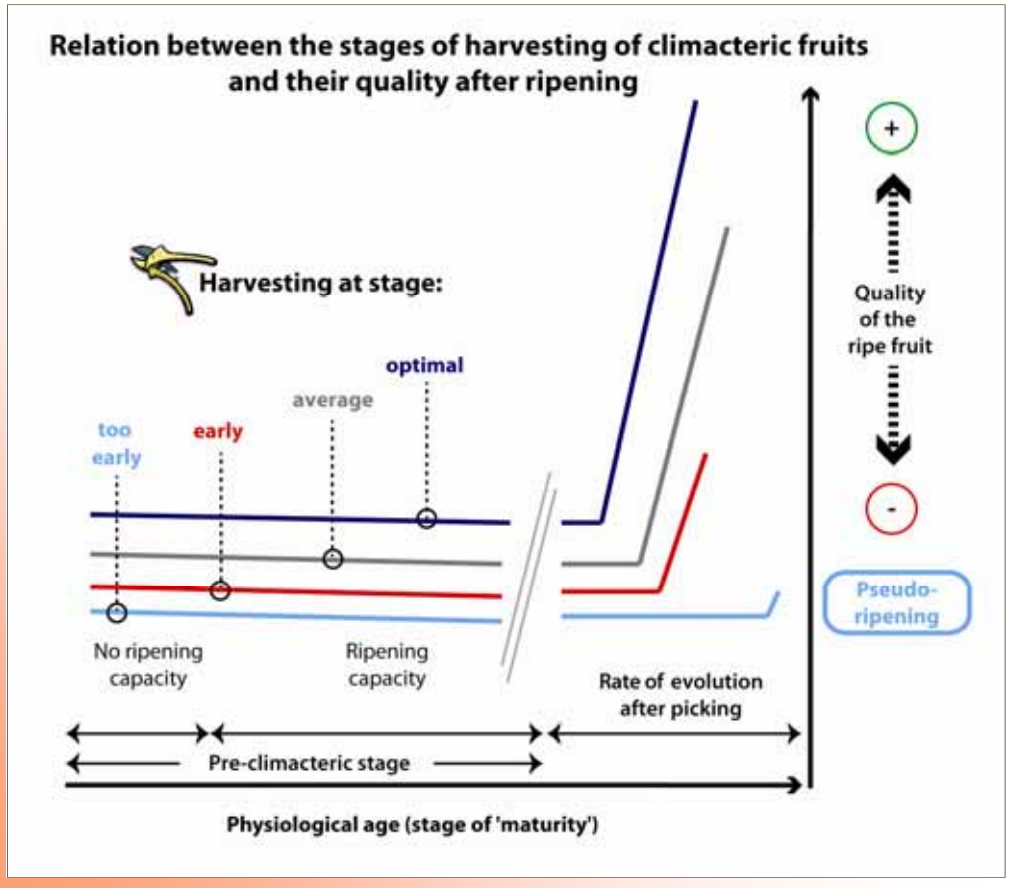
must be created artificially for ripening to be completed.

It is therefore an exaggeration to say that a climacteric fruit can only ripen after being picked. First, factors that can modulate the ripening of the fruit must be taken into account for each species or variety. Second, there should be a clear separation between the physiology of the fruit, which can ripen on the plant but without the quality required and sales constraints (fruits ripened after picking).

Ripening capacity and the quality of ripe fruits

Market constraints mean that certain climacteric fruits must be picked before they are ripe. So a stage of physiological development must be set (during the pre-climacteric phase) that allows the fruits to ripen after picking. The problem is that of identifying the best moment. This intermediate stage does not exist in nature as fruits are intended to ripen on the plant. From the physiological point of view, it is difficult to identify specific indicators for this stage, in contrast with the ripe stage for which several indicators are easy to read.

Possible references for the assessment of an appropriate harvest stage will depend on the types of fruit and the criteria will sometimes be empirical: shape, colour initiation, appearance of the peduncle, etc. These references vary in accuracy and give an average indication of 'intermediate' ripeness. Most of the more pertinent features such as firmness, sugar content and pulp colour are destructive indicators. Fruit batch validation will therefore be performed on the



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basis of sampling—adding the variability between one fruit and another.

Accurate assessment of the 'green mature' is thus a key factor that leads to a final point that is doubtless the most important feature of fruit management: the link between the stage of maturity at picking and the quality of the ripe fruit. As has been mentioned, the fruit on the plant takes up various compounds. A biochemical process takes place during ripening, with the breakdown of compounds and the action of precursors that results in the synthesis of new compounds. However, these changes can only reach the stage of development reached by the fruit at harvesting. The graph on the previous page shows the simulation of the case of a climacteric fruit that must be picked during its pre-climacteric phase, with harvest stages ranging from 'too early' to 'fairly suitable'. After storage, the fruits will be ripened or will ripen unaided in the distribution channels. It is clear that the later the harvest, the smaller the conservation potential and the faster the start of ripening with final quality guaranteed. Market release constraints give the favouring of high conservation potential a certain legitimacy but this affects the final quality of the ripe fruit. Furthermore, in addition to displaying less interesting taste qualities, fruits picked at an early stage are sensitive to storage conditions (susceptibility to cold, faster loss of moisture). These factors may accelerate deterioration and thus affect the final quality of the produce sold.

More of a problem, this quest for fruits with high storage potential may result in the harvesting of fruits that have not yet attained full ripening capacity. They cannot truly ripen. The acid content falls during storage and this slightly improves the sugar:acid ratio and there is logically a loss of firmness caused more by senescence (moisture loss and withering) than by ripening. From the technical point of view, this is more 'pseudo ripening ' than true ripening ■

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Lines to be followed...

New approaches in agricultural practices (sustainable systems, mastery of input management, agro-ecological and environmental approaches) will improve the homogeneity of produce.

In parallel, new measurement apparatus such as infrared spectrophotometry (IRS) and the measurement of fruits by compression are non-destructive methods. If it can be shown that it is possible to establish a firm link between the values at a degree of ripeness and as each fruit can be measured, the variability of batches after sorting can be kept to a minimum.

Finally, the increasing mastery of postharvest technology means that know-how can be optimised—logistics, traceability, the performance and regulation of equipment (storage rooms, grading and packing lines, etc.). Batches will thus be better managed.

This progress must not be separated from the concept of the compromise required between storage potential for release on the market and final quality that must match consumer expectations. With the assurance of being able to supply quality produce, the various sectors will have a major asset for conserving and developing their markets.