FRUIT RIPENING

Ripening is the process by which fruits attain their desirable flavour, quality, colour, palatable nature and other textural properties. Ripening is associated with change in composition *i.e.* conversion of starch to sugar. On the basis of ripening behavior, fruits are classified as climacteric and non-climacteric fruits.

Climacteric: Climacteric fruits are defined as fruits that enter 'climacteric phase' after harvest *i.e.* they continue to ripen. During the ripening process the fruits emit ethylene along with increased rate of respiration. Ripe fruits are soft and delicate and generally cannot withstand rigours of transport and repeated handling. These fruits are harvested hard and green, but fully mature and are ripened near consumption areas. Small dose of ethylene is used to induce ripening process under controlled conditions of temperature and humidity.

Climacteric fruits are:

*Mango	*Banana	*Papaya
*Guava	*Sapota	*Kiwi
*Fig	*Apple	*Passion fruit
*Apricot	*Plum	*Pear

These fruit in fully ripe state are too delicate to withstand transportation over long distances and should preferably be ripened near the consumption area.

Non-Climacteric: Non-climacteric fruits once harvested do not ripen further. Non-climacteric fruits produce very small amount of ethylene and do not respond to ethylene treatment. There is no characteristic increased rate of respiration or production of carbon dioxide.

Non-climacteric fruits are:

*Orange	*Mousambi	*Kinnow
*Grapefruit	*Grapes	*Pomegranate
*Litchi	*Watermelon	*Cherry
*Raspberry	*Blackberry	*Strawberry

* Carambola	*Rambutan	* Cashew

In order to improve external skin colour and market acceptance, citrus like orange, lemon, mousambi and kinnow can be treated with ethylene, as a **de-greening** agent. Ethylene treatment breaks down the green chlorophyll pigment in the exterior part of the peel and allows the yellow or orange carotenoid pigments to be expressed.

Technologies for ripening of fruits

Lack of easier and rapid methods for uniform ripening poses a major problem in the fruit industry. Almost all methods of ripening, either conventional or the modern chemical methods, come with their own merits and demerits.

There are several simple technologies and methods available today for farmers for proper ripening. Normally, the number of days taken for edible ripening varies for different fruits and prevailing climatic conditions. For instance, it takes about 5 to 6 days for mangoes and 6 to 7 days for sapotas to ripen. Under natural conditions, ethylene, a ripening hormone produced by the plant plays a major physiological role in the ripening process.

- A simple technology practiced in households to trigger ripening is to keep un-ripened and ripened fruits together inside an air tight container. Since the already ripened fruits release ethylene, ripening will be faster.

Mango ripening in air tight rice bin

- Another method is to place the fruits intended for ripening inside an air tight room and induce ripening through smoking inside smoke chambers. Smoke emanates acetylene gas. Several fruit traders follow this technique to achieve uniform ripening especially in edible fruits like banana and mango. But the major drawback of this method is that the fruits do not attain uniform colour and

flavour. In addition, the persistence of smoke odour on the product impairs its quality

- Spreading unripe fruits as layers over paddy husk or wheat straw for a week to ripen is an another alternative.

Mango ripening using paddy straw

- Another practice is that some farmers dip unripe mature fruits in 0.1 per cent ethrel solution (1 ml of ethrel solution in 1 litre of water) and wipe it dry. The fruits are then spread over a newspaper without touching each other and a thin cotton cloth is covered over this. In this method, the fruits will ripen within two days.
- In one of the simple and harmless techniques, 10 ml of ethrel and 2 gm of sodium hydroxide pellets are mixed in five litres of water taken in a wide mouthed vessel. This vessel is placed inside the ripening chamber near the fruits and the room is sealed air tight. About a third of the room is filled with fruits leaving the remaining area for air circulation. Ripening of fruits takes place in about 12 to 24 hours. In order to reduce the cost of chemical, some ethylene releasing fruits such as papaya and banana can also kept in the same room.
- Ethylene gas filled in pressurized cans promote fruit ripening in 24-48 hours

Uniform ripening of papaya fruits using ethylene gas

Fruit ripening using calcium carbide

Most climacteric fruits in India are ripened with industrial grade calcium carbide. Industrial-grade calcium carbide usually contains traces of arsenic and phosphorus, and, thus, use of this chemical for this purpose is illegal in most countries. In India too, use of calcium carbide is strictly banned as per **PoFA (Prevention of Food Adultration) Act [Section 44AA**]. Calcium carbide, once dissolved in water, produces acetylene which acts as an artificial ripening agent. Acetylene is believed to affect the nervous system by reducing oxygen supply to brain. Arsenic and phophorus are toxic and exposure may cause severe health hazards.

Workers at a fruit market using calcium carbide to ripen raw mangoes

The only safe and worldwide accepted method is using ethylene, which is a natural hormone for ripening when done under controlled temperature and relative humidity conditions.

Ethylene being a natural hormone does **not pose any health hazard for consumers** of the fruits. It is a de-greening agent, which can turn the peel from green to perfect yellow (in the case of bananas) and maintain the sweetness and aroma of the fruit, thus value addition in the fruit is possible as it looks more appealing. It has been known for a long time that treatment of unripe fruits with ethylene would merely stimulate natural ripening until the fruit itself starts producing ethylene in large quantities.

Methods of applying ethrel

Method selected for applying ethylene depends on cost, convenience and safety factors. Use of diluted ethylene gas mixtures is safer than using pure ethylene, which is explosive and flammable at concentrations of 3% or higher. Fruit to be ripened ideally is placed in an airtight ripening room maintained at a constant temperature (18-21^{o}C for most fruits, but 29-31^{o}C in mango). Optimum storage and ripening temperatures for a few fruits are given below.

Commodity	**Ethylene conc.(ppm)**	**Ethylene exposure time (hr.)**	**Ripening temp. ^{o}C**	**Storate Temp.^{o}C**
Avocado	10-100	12-48	15-18	4.4-13
Banana	100-150	24	15-18	13-14
Honey dew melon	100-150	18-24	20-25	7-10
Kiwifruit	10-100	12-24	0-20	0.5-0
Mango	100-150	12-24	20-22	13-14
Orange degreening	1-10	24-72	20-22	5-9
Stone fruit	10-100	12-72	13-25	-0.5-0

There are two methods of exposing fruit to ethylene. Trickle method involves trickling ethylene gas into room so as to maintain a concentration of 10 ul per litre, usually for a period of 24 hours. During this time, relative single initial charge of ethylene at a concentration of 20 to 200 ul /litre. Room is then ventilated after 24 hours to prevent carbon dioxide exceeding 1% concentration, which would retard ripening. Rooms that are poorly sealed are packed in vented cartons stacked on pallets, and fruit temperature is controlled by forced air circulation as in a cooling facility. A small fan can be used to ensure a uniform continuous flow of ethylene into and through the room. Forced-air ripening provides more uniform temperature and ethylene concentration throughout ripening room.

Ripening chambers

Catalytic generator for ethylene production in ripening rooms

Ripening can also be initiated using ethylene generated by passing ethanol over a bed of activated alumina. This method is safer than using pure ethylene gas. Ethylene-releasing compounds such as ethephon (2-chloroethy1 phosphonic acid) are sometimes used to ripen tomatoes destined for processing. When using ethephon as spray, amount of ethylene released will increase as pH and/or relative humidity increase.

Optimal ripening conditions for fruit ripening

Temperature	18 to 25^{o}C
Relative humidity	90 to 95%
Ethylene concentration	10 to 100 ppm
Duration of treatment	24 to 74 hours depending on fruit type and stage of maturity
Air circulation	Sufficient to ensure distribution of ethylene within ripening room
Ventilation	Require adequate air exchange in order to prevent accumulation of O_2, which reduces effectiveness of C_2H_4.

Degreening

Controlled degreening sometimes is carried out on citrus grown in tropics. Many citrus cultivars mature before green colour disappears from peel. Breakdown of chlorophyll and production of a rich orange colour require exposure to low temperature during maturation, and this explains why mature citrus frequently is sold green on markets in humid tropics, where even night temperatures may not drop much below 25^{o}C. The ceiling of room is relatively high, allowing boxes to be stacked at least four boxes high. A false ceiling is added to provide for adequate air.

Degreening is carried out in ripening rooms, with same ethylene concentrations as above. this process takes 2 to 3 days, and it is again necessary to ventilate daily to ensure that carbon dioxide levels do not exceed 1%. The most rapid degreening occurs at temperatures of 25 to 30^{o}C but the best colour (concentration of peel carotenoids) occurs at 15 to 25^{o}C.

Sources

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