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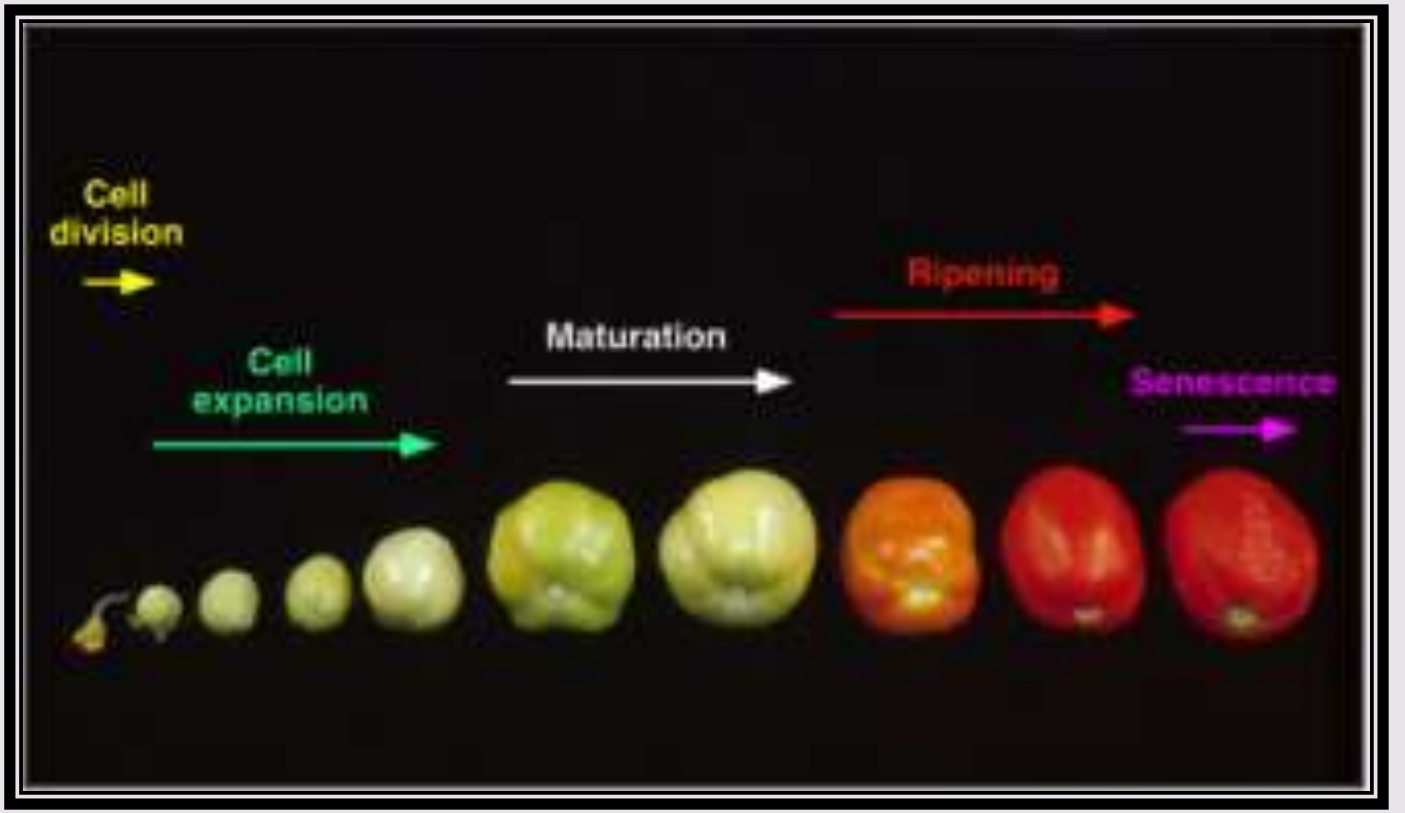
Biochemical and physiological changes during ripening



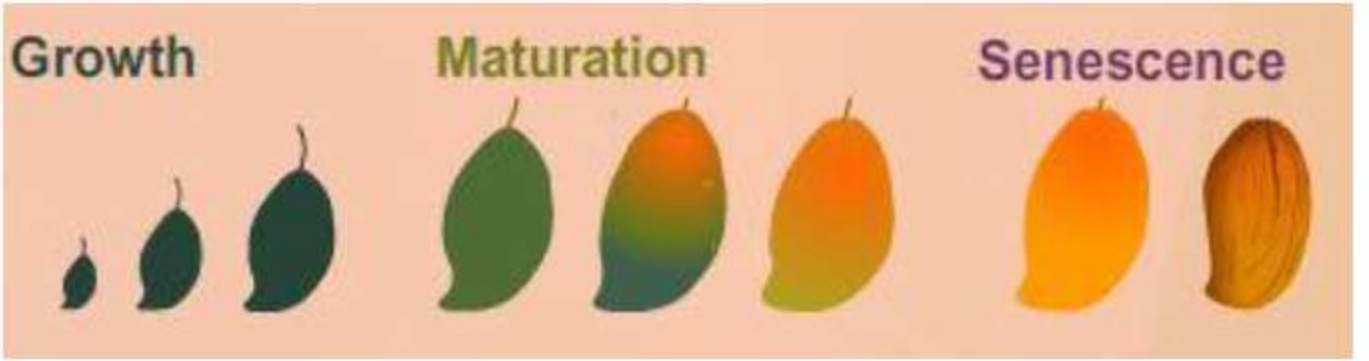
INTRODUCTION

- Ripening is the process by which fruits attain their desirable flavor, quality, color, palatable nature and other textural properties.
- Ripening is associated with change in composition *i.e.*
  - **Conversion of starch to sugar.**
  - **Change in colour**
  - **Change in firmness**
  - **Shape and size**
  - **Odour /smell**

Physiological Changes

- Fruits and Vegetables are living entities and diverse in structure, composition and physiology.
- They have the typical plant cell system.
- The life of fruit and vegetables can be conveniently divided into three major physiological stages following germination

These are: Growth → Maturation → Senescence



Physiological Changes

- **Growth** - involves cell division and subsequent cell enlargement, which accounts for the final size of the produce.
- **Maturation** - usually commences before growth ceases and includes different activities in different commodities. Growth and maturation are often collectively referred to as the development phase.
- **Senescence** - is defined as the period when synthetic (anabolic) biochemical process gives way to degradative (catabolic) process, leading to ageing and finally death of the tissue.

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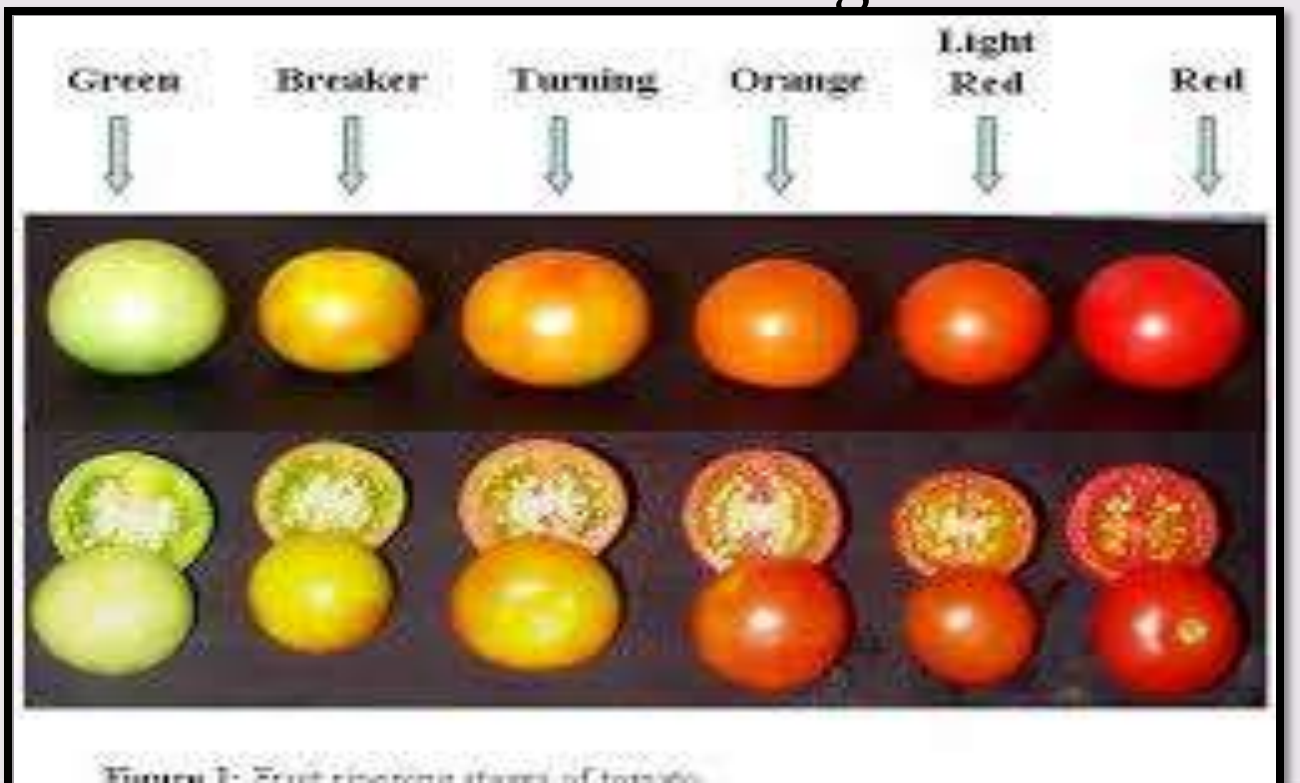
- **Ripening** - is a phase of qualitative change which occurs in fruits particularly, after completion of maturation, during which the fruit becomes acceptable for consumption in terms of taste and flavour.
- Ripening occur during the later stages of maturation and is the first stage of senescence.



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Respiration

- One of the major physiological and biochemical change which occur in fruits and vegetables is a change in the pattern of respiration.
- If the respiration rate of a fruit or vegetable is measured as their O_2 consumed or CO_2 evolved during the course of the development, maturation, ripening and senescent period, a characteristic respiratory pattern is observed.
- The respiratory pattern also impacts the pattern of evolution of ethylene. Based on this pattern, fruits can be classified into ‘climacteric’ and ‘nonclimacteric’.

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Respiration

- Few fruits exhibit the pronounced increase in the respiration (increase in CO_2 and C_2H_4) coincident with the ripening, such increase in the respiration is known as respiratory climacteric, and this group of fruits is called climacteric.
- Respiration is a process in which stored organic materials (carbohydrates, protein, and fat) are broken down into simple end products with release of energy. Oxygen is used in this process and carbon dioxide is produced.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{energy (686 k.cal)}$$

Difference between climacteric and non-climacteric fruits

	Climacteric Fruit (CF)	Non-climacteric Fruit(NCF)
1	Normally they ripen after harvest	Fruit that does not ripen after harvest. Ripen on the plant itself.
2	The quality of fruit changes drastically after harvest characterized by softening, change in colour and sweetness. (except in avocado, which will ripen only after detached from the plant)	The quality do not change significantly after harvest except little softening. Do not change to improve their eating characteristics
3	Exhibits a peak in respiration	Does not exhibit a peak
4	More ethylene is produced during ripening	Little / No ethylene production
5	Significant increase in CO_2 production	No significant increase in CO_2 production
6	Significant increase in CO_2 production	Slowly
7	Decrease in internal oxygen concentration	More
8	Low concentration of ethylene 0.1-1.0 µ L/L/day is sufficient to hasten ripening	Not much response is seen to exogenous application of ethylene.
9	Eg - Many except in the apposite column	Eg- Bell pepper, Blackberry, Blueberry, Cacao, Cashew apple, Cherry, Citrus sp.,Carambola, Cucumber, Eggplant, Grape, Litchi, Loquat, Okra, Olives, Pea, Pineapple, Pomegranate, Pumpkin, Raspberry, Strawberry, Summer squash, Tart cherries, Tree tomato and *rin* & *nor* tomato, Watermelon
		

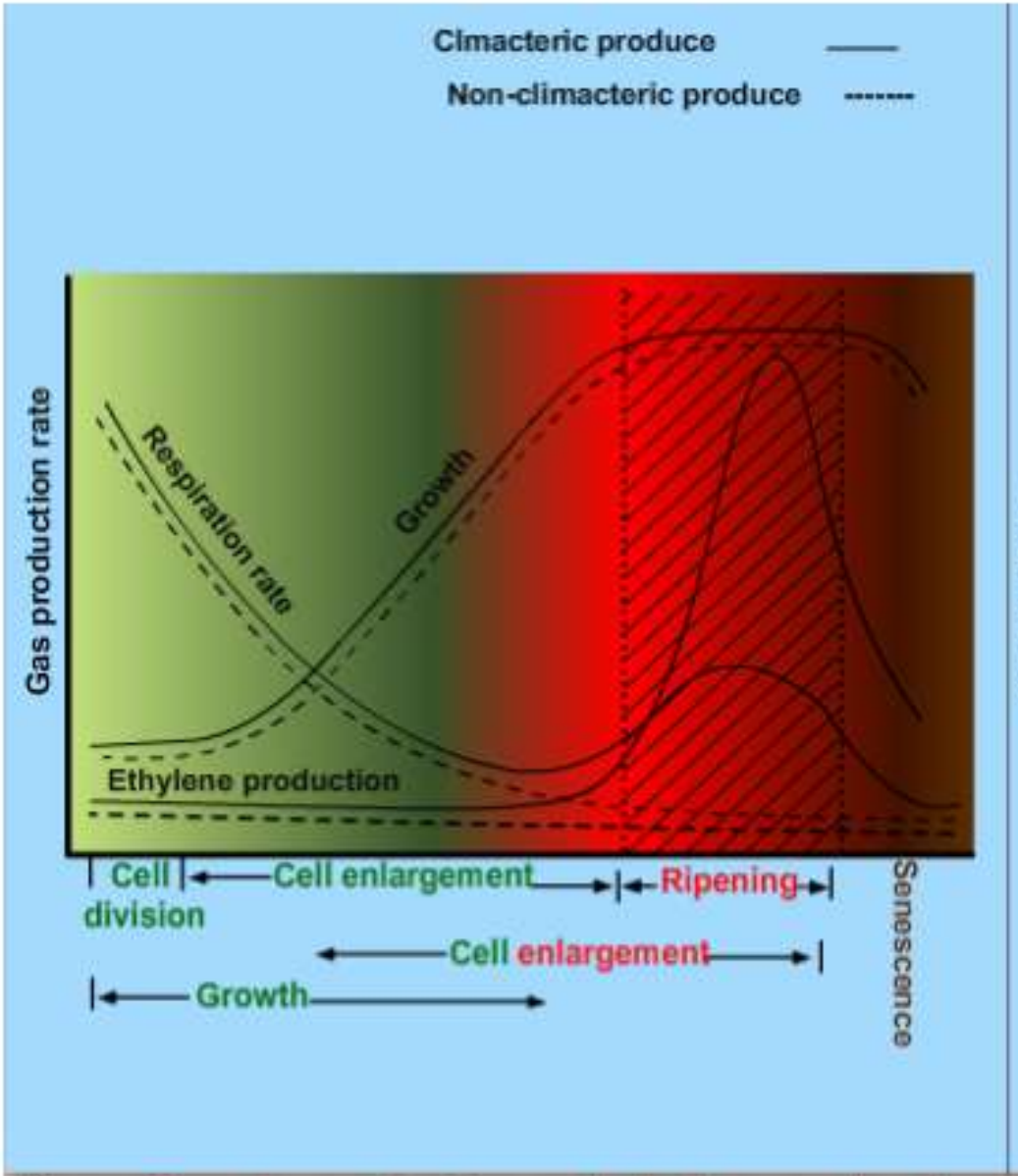

Fig.3.1 Growth, respiration and ethylene production patterns of climacteric and non-climacteric plant organs

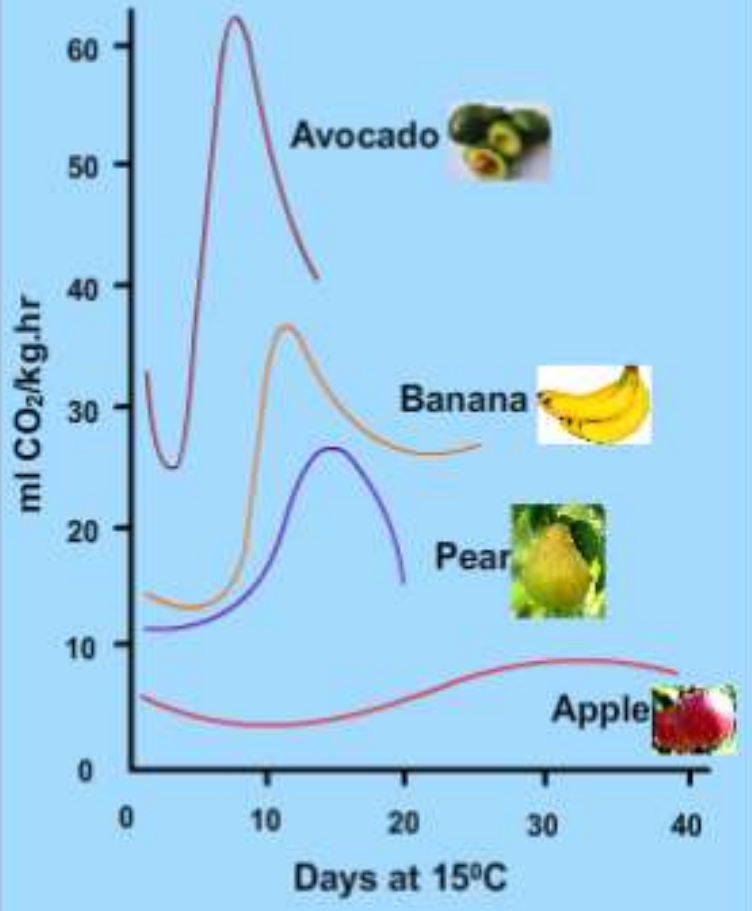

Fig.3.2 Respiratory patteren of harvested climacteric fruits

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Classification of horticultural commodities according to their respiration rate

CLASS	Range at 5° C ($mgCO_2Kg^{-1}\ hr^{-1}$)	COMMODITIES
Very low	**< 5**	Dates, Dried fruit and vegetables, Nuts, *etc.*
Low	**5 - 10**	Apple, Beet, Celery, Citrus Fruits, Garlic, Grapes, Kiwi Fruit, Onion, Papaya, Pineapple, Potato (Mature), Sweet Potato, Watermelon *etc.*
Moderate	**10 - 20**	Apricot, Banana, Cabbage, Carrot (Topped), Cherry, Fig, Lettuce (Head), Mango, Peach, Pear, Plum, Potato (Immature), Radish (Topped), Tomato, Summer squash
High	**20 - 40**	Avocado. Carrot (with tops), Cauliflower, Leeks, Lettuce (Leaf), Radish (with tops), Raspberry
Very high	**40 - 60**	Artichoke, Bean Sprouts, Broccoli, Brussels sprouts, Cut flowers, Green Onion, Okra
Extremely high	**> 60**	Asparagus, Mushroom, Parsley, Peas, Spinach, Sweet corn

Respiratory Pattern

- Climacteric
- Non climacteric

	Climacteric	Non climacteric
Respiration	Increase	Not shows respiratory climacteric
Ethylene	More production	Less amount
Detachment ripening	occurs	On tree only
Fruits	Apple,Apricot,Banana, Guava,Kiwifruit	Cherry,Cucumber,Grape, Grapefruit,Lemon

Factors responsible for the respiration

1. Temperature
2. Relative Humidity
3. Gas composition in the ambient and in the cell
4. Moisture content of the tissue
5. Wounding or injury
6. Type of the plant parts
7. Stage of development of tissue
8. Surface area to volume of the produce
9. Pre-harvest treatments and PH methods
10. Chemical composition of tissue
11. Size of the produce
12. Presence of natural coating on the surface

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Ethylene

- Ethylene is a natural plant hormone released by all plant tissues and microorganisms.
- It is also called ‘Ripening hormone’, as it plays an important role in ripening process. Low concentration of 0.1-1.0 microlitres is sufficient to trigger the ripening process in climacteric fruits.
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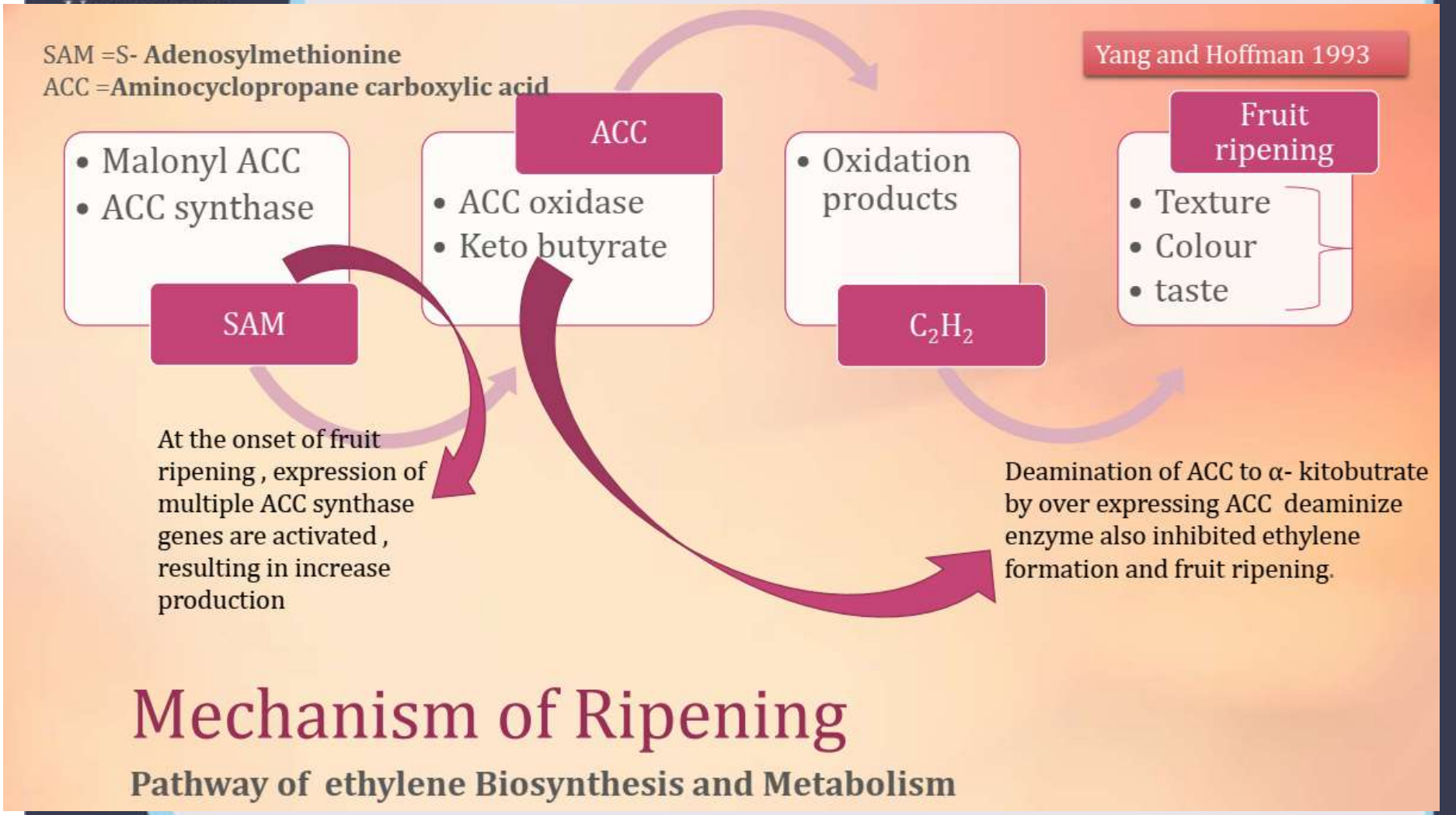
Ethylene Biosynthesis



Mechanism of Ripening

Pathway of ethylene Biosynthesis and Metabolism

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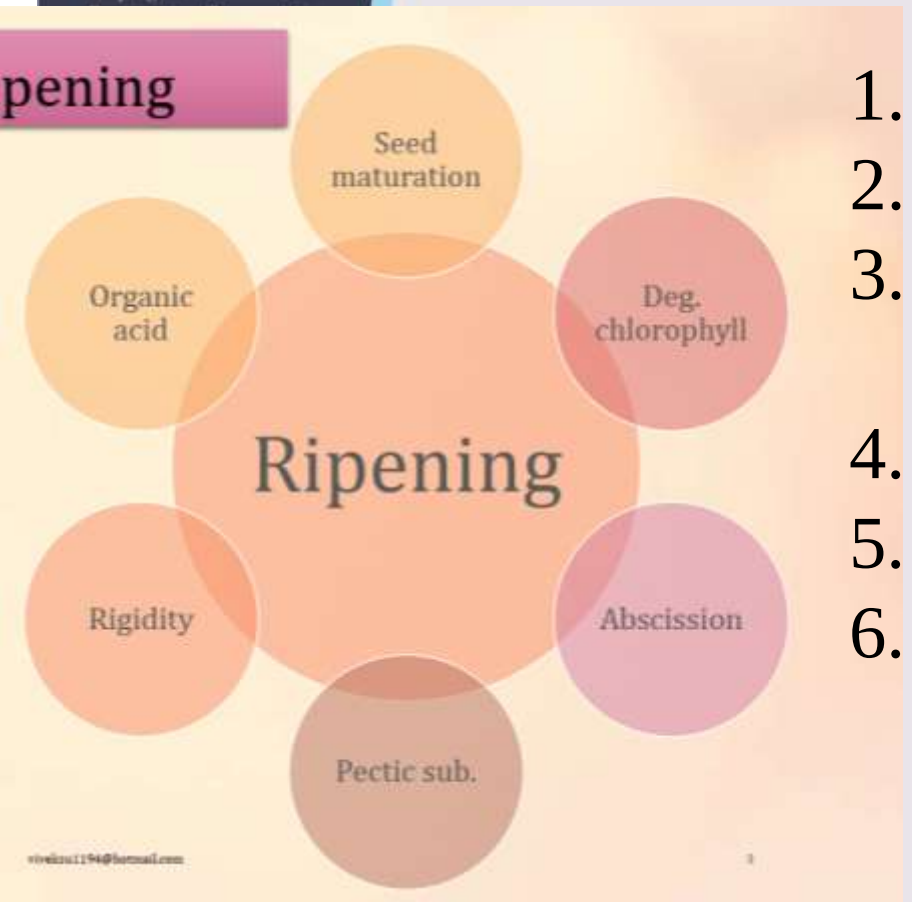
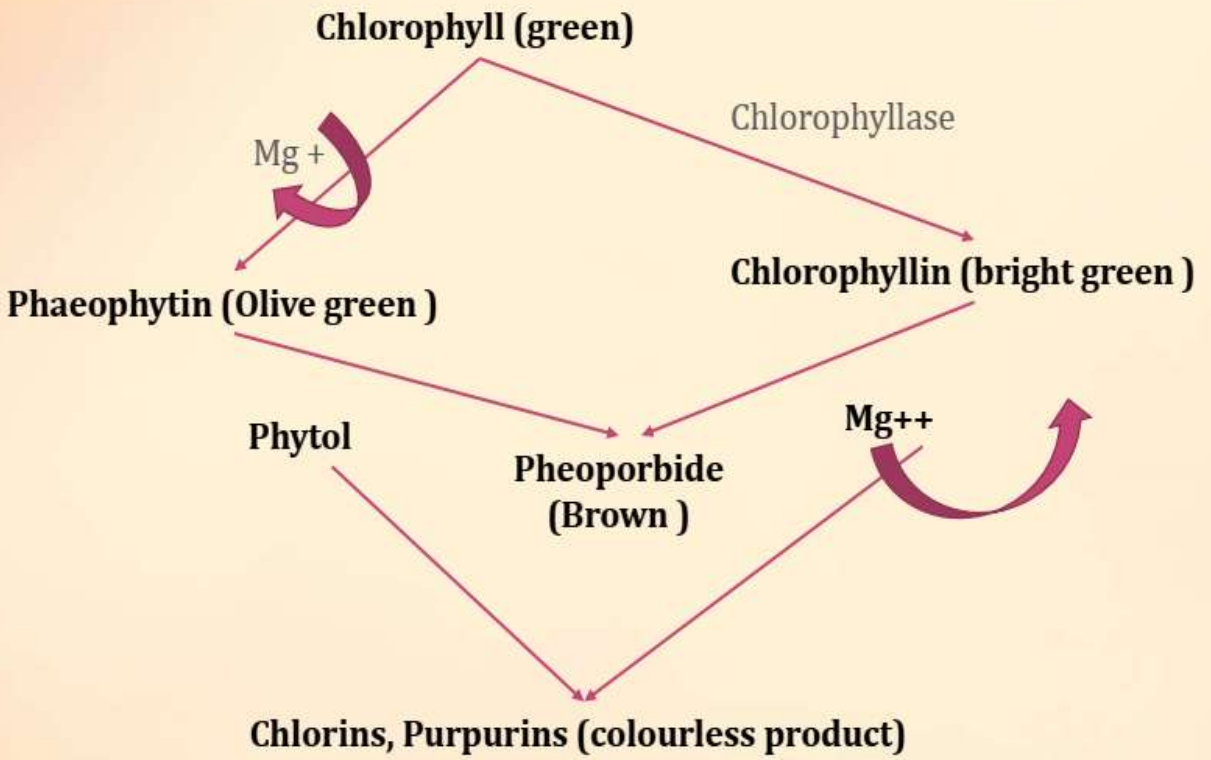
Biochemical Changes



1. Cell wall changes
2. Degradation of chlorophyll
3. Conversion of starch in to sugars
4. Decrease in tanins and phenols
5. Decrease in acidity of the fruit
6. Development of characteristic flavour

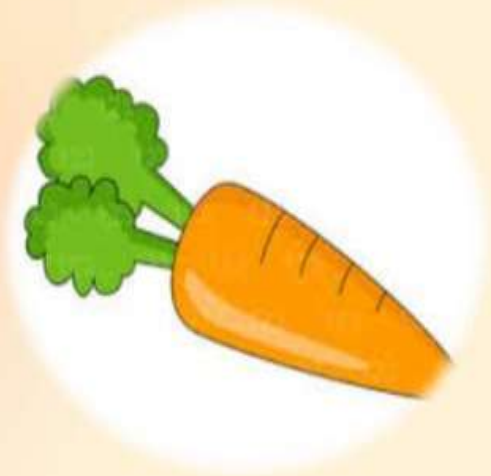
Degradation of Chlorophyll and Pigment Synthesis



- Degradation of **chlorophyll** due to **Chlorophyllase** enzyme.
- Splitting of **chlorophyll** into **Phytol chain** and **porphyrin.**
- Loss of Mg ++ ion and conversion of **porphyrin** into **Phaeophytin.**
- Change in **tetrapyrolic** chain and it becomes **bilviridin.**
- **Oxidation** or saturation of double bonds.

Metabolic Changes

- Increases in biosynthesis
- Evolution of ripening hormone
- Increase in respiration mediated
- Alternation of cell structure
- Hydration of cell wall
- Decrease in structural integrity
- Increase in intercellular space



Enzyme	Mode of action
α Amylase	Mixture of glucose and maltose
Starch phosphorylase	Glucose 6-phosophate
α (1-6) glucosidase	Amylopectin

Product	Compound
Apple	Ethyle 2- methyle butyrate
Banana	2 hexanol
Lemon	Citral

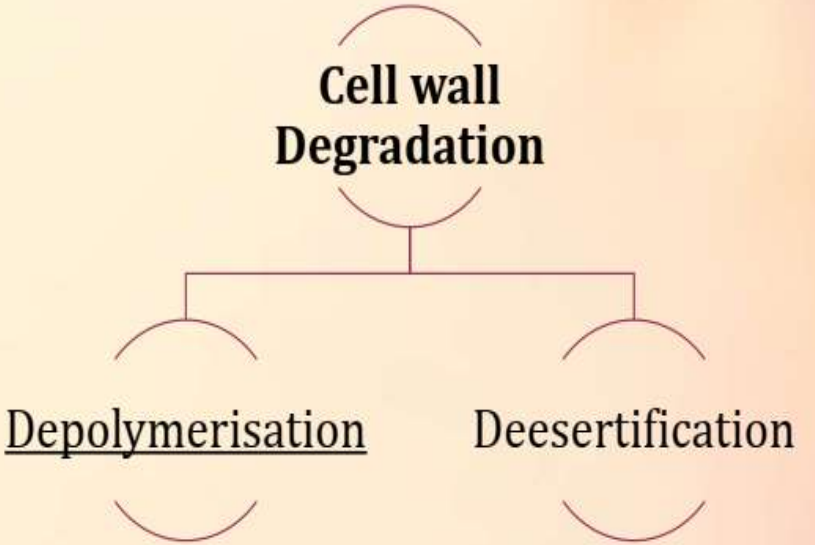
Hydrolysis and Aroma

Starch to sugars .....

Aroma volatile after ripening .....

Texture and Cell wall changes

Textural changes	Enzyme degradation of polysaccharides
	Different rates i.e. Degree
	Breakdown of starch
	Pectic substance
	Hydrolysis starch- firmness
Cell wall breakdown	PG (Polygalacturonase)
	PME (Pectin methylesterase)
	Other hydrolases



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Phenolic Compound

Astringency to fruit e.g. **Tannins.**

Involve in **oxidative browning** due to **Polyphenoloxidase**

S NO	Crop	Phenol	Status
01.	Grapes	Flavon-3-ol monomers	Decreases
02.	Loquat	Hydrobenzoic acid	Decreases
03.	Citrus	Limonoids	Decreases

- Softening –Pectin esterase
- Oxidation- Catalse and peroxidase
- Glycolytic action- Glucose phosphate isomerase
- Hydrolytic action –Amylase cellulose, beta amylase
- Pigmentation- Chlorophyllase

Enzyme Activity

Many of the chemical and physical affects during ripening and after ripening processes are attributed to the enzyme action.

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Physical condition – Chemical cause

Chemical cause-Physical condition

Unripe Fruit

- Green- Chlorophyll
- Hard - Pectin
- Sour – Acid
- Mealy- Starch
- Odourless- Large orgs

- Hydrolase
- Pectinase
- Kinase
- Amylase
- Hydrolysis

Ripe fruit

- Anthocyanin-Red
- Less pectin-Soft
- Neutral
- Sugar sweet +juicy
- Small orgs+odor

Enzymatic action

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Regulation of Ripening

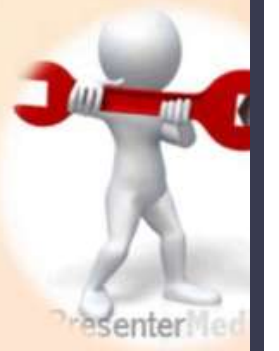
Ethylene regulation

Regulation of O_2 and CO_2
- MAS
- CAS

Chemical treatment
- Calcium
- 1MCP methylcyclopropane

Bioregulatores
- Auxin GA,CK
- Ehhylene ,ABA

Ionized radiation
- Gamma



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Wishing to be friends
is quick work,
but friendship is
a slow ripening fruit.

Aristotle

Thanking You