THE LIVING FRUIT

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Fruit, like other living systems, go through a series of developmental stages culminating in the formation of a mature organ.

In citrus fruit, development can be divided into three stages (Figure 1).

Stage I: Fruit formation, basic structural components are formed.

Stage II: Characterized for its maximum growth in volume and fresh weight. This accelerated growth period is of critical importance in determining fruit size and quality. Fruit at this stage can be adversely affected by stress conditions such as lack of water, excessive heat, and lack of nutrients.

Stage III: Maturation period, the flavedo changes color and the rate of growth in terms of dry and fresh weight accumulation decline.

During the latter two stages and particulary Stage II, sugars (mainly sucrose) produced in the leaves by photosynthetic CO_2 fixation, are translocated to the fruit where they serve as building blocks to support growth. As it enters the fruit, sucrose goes through a series of transformations in order to supply the growing fruit with all its needs. Some of the products of sucrose breakdown are rapidly utilized by the growing fruit, while others (sugars and acids) are stored in the juice sacs (Figure 2). These will be later utilized during the postharvest life of the fruit.

During Stage II, the fruit is a very dynamic system of extreme firmness, strength, and high respiratory rates; however, it is a critical stage for any stress during this period will irreversibly affect the final product. As the fruit reaches Stage III or maturation, the flavedo turns orange or yellow, the fruit softens and the rates of metabolic activity decline. Additionally, an increase in the concentration of soluble solids and a decrease in acidity (increase in pH) are noted.

At maturity, the citrus fruit is classified as a hesperidium (Figure 3): a non-dehescent (does not open as bean pods) fleshy fruit with conspicuous septations lined with succulent hairs (2). As a non-climacteric fruit, citrus does not store insoluble carbohydrates such as starch (3). Instead, massive amounts of sugars and acids are stored which are the principal parameters of fruit quality (4). After harvest, the sugars and acids become the energy source to sustain life of the fruit and the physiological deterioration of the fruit commences. This is a natural process and will continue throughout the remaining life of the fruit.

It is our mission to find ways to slow down the rate of postharvest maturation and deterioration, as well as to make the fruit more appealing while protecting it from the invasion of pathogens. The citrus fruit has limited postharvest life and extreme care must be taken to protect it from mechanical injury and accelerated natural senescence. Examples of common postharvest events that accelerate decay are physical injury, high temperatures, exposure to ethylene, and invasion of pathogens.

A temperature increase of 18°F will double or triple the rate of metabolic reactions. For example, a Valencia orange can be stored at 35°F for 20 weeks, but less than three weeks at 81°F. Increased respiration results in faster utilization of sugars and acids, and production of off flavor components. Additional factors that can alter the respiratory activity of citrus fruits during storage include fungal infection (6), precooling (7), rough handling (5,8), pressure from packing (6,8), ethylene (6), elevated CO_2 levels (9), and waxing (10).

Storage conditions are aimed at slowing down the rate of deterioration, however, additional prevention could be achieved with proper handling practices in the field, careful packingline operations, and appropriate transporation and marketing conditions.

References

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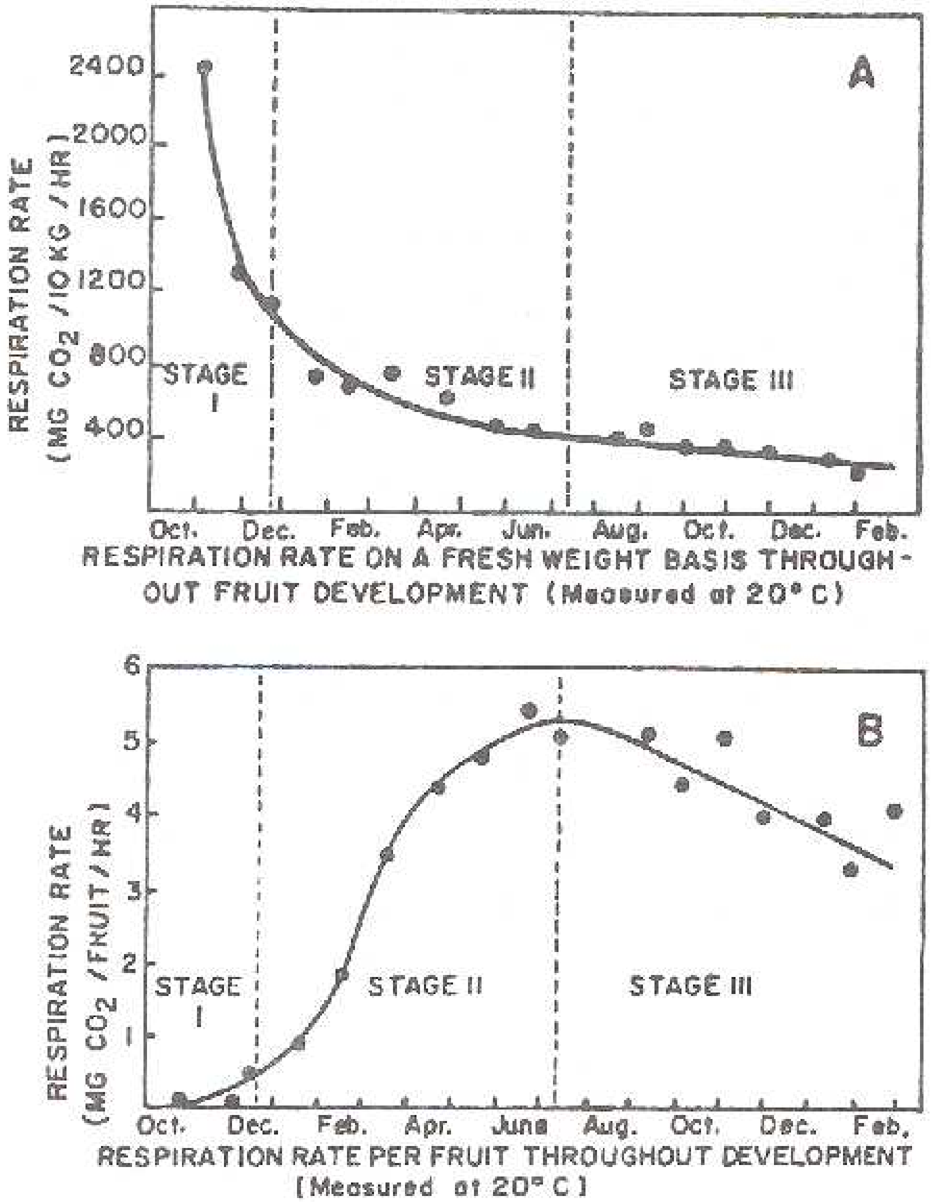

Figure 1. Respiration during fruit development. A--Expressed in the usual manner as CO_2 evolution per unit fresh weight. B--Expressed as CO_2 evolution per fruit, a form that much more clearly defines the stages of fruit development (1).

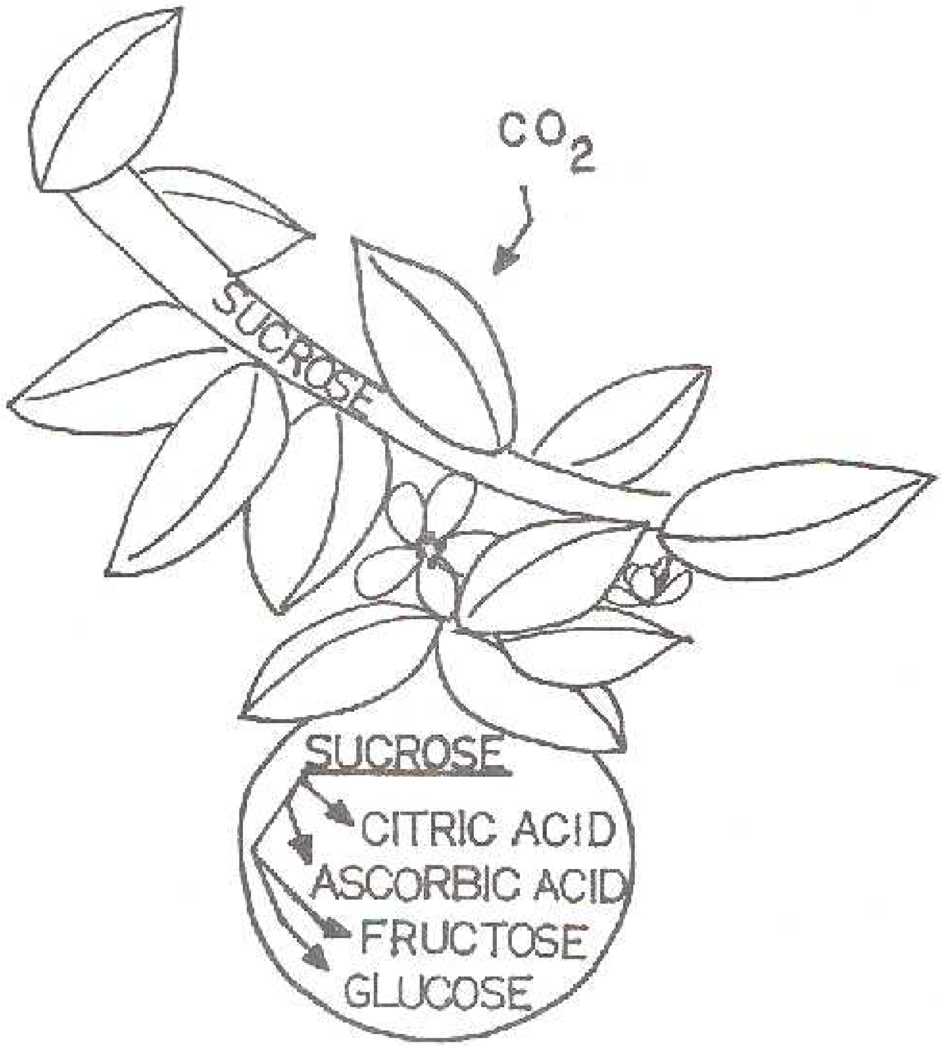

Figure 2. Diagramatic representation of CO_2 interconversion in the citrus tree (diagram by Dr. L. Wicker).

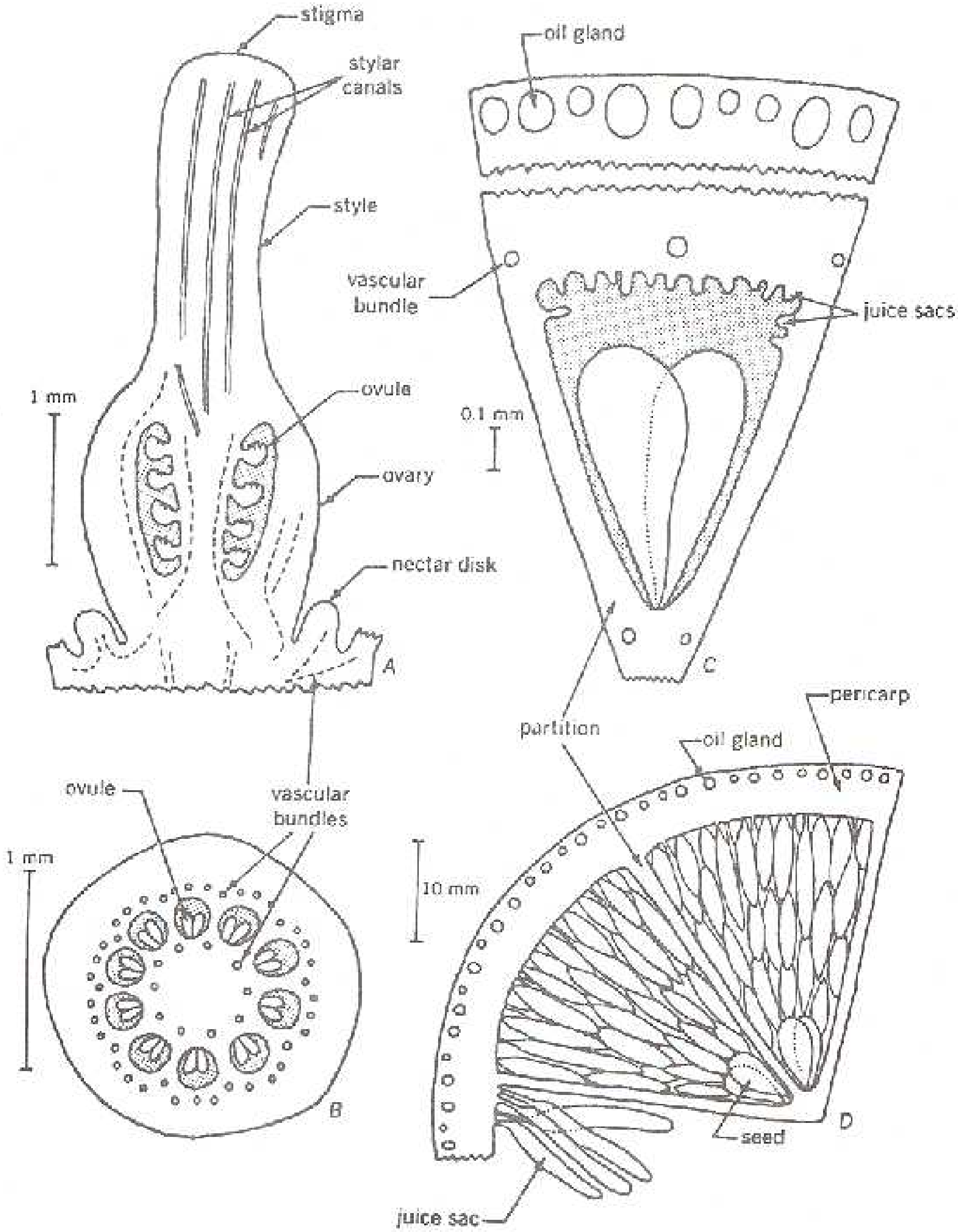

Figure 3. Citrus fruit. A, B, young ovary from flower of Citrus aurantifolia (lime) in longitudinal (A) and transverse (B) sections. C, part of transection of young fruit of C. sinensis (orange) including one carpel. Juice sacs in early stage of growth. D, diagram of orange fruit including two carpels and part of a third. Juice sacs fill the locules (2).