

Coloring of Fuji Apples by Bagging

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Poor red coloration is often a serious problem in the culture of Fuji apples. To overcome this situation, the practice of fruit bagging is common in Japan. This article describes Fuji bagging practices and provides information on some physiological characteristics of Fuji fruit related to its poor coloration behavior.

The high popularity of Fuji is due to its good taste and excellent keeping quality. Unfortunately, however, Fuji does not color well. This can be a serious problem, particularly in regions where weather conditions are not favorable for skin color development. From the time of its introduction in 1963, growers have recognized the tendency of Fuji toward rather poor coloration. They have developed various management practices to improve color, such as fruit bagging, leaf removal close to individual fruits, and reflective mulches as well as growth control practices (fertilization, irrigation, pruning, etc.). The coloration behavior of nonbagged Fuji as well as bagged should be considered for producing highly colored fruit (Kikuchi et al., 1997).

Why Does Fuji Develop Poor Red Color?

Fuji has difficulty coloring well compared to Jonathan and Red Delicious, and careful management practice for coloration is necessary for its culture. The answer to the question is that the effects of light and temperature on color development of Fuji are different from other cultivars like Jonathan. Both light and temperature are very important factors for color development of apples. Fuji produces little anthocyanin (red color pigment) when only visible light is given (wave length of 400 to 700 nm). Therefore, ultraviolet irradiation (UV-B, 280-320 nm) is imperative for better coloration of this cultivar (Arakawa et al., 1986). This contrasts with other cultivars, such as Jonathan, which color fairly well under visible light, particularly when the fruit is approaching full ripening (Arakawa, 1988). Fuji apples require a higher intensity of light than do other cultivars in order to produce the same quantity of anthocyanin. The intensity of ultraviolet rays diminishes sharply on an overcast day, or even on a sunny day, within the tree canopy (Robberecht, 1989). Therefore, sunny weather during the coloration period and good within-canopy light conditions are particularly important for the culture of highly colored Fuji.

Fuji apples develop red color best at 15 to 20°C (59 to 68°F) (measured at the surface of the fruit), lower than the temperature range for Jonathan (20 to 25°C; 68 to 77°F) (Arakawa, 1991).

Coloration sharply declines in Fuji as the temperature either goes up or down from the optimum range. Therefore, it is difficult to produce highly colored Fuji in warm areas.

How Does Bagging Affect Fuji Coloring Behavior?

Bagging does not change the effects of light and temperature on coloring of Fuji. However, it changes the relationship between coloring and ripening. As typically demonstrated with Jonathan fruit, red color of apples usually develops rapidly with the advance of fruit ripening due to an increase in the anthocyanin-producing ability of the fruit (Arakawa, 1991). This ability reaches a maximum level at the full-ripening stage of the fruit, and then declines sharply. Nonbagged Fuji is somewhat specific in its coloring behavior: red color development is slow and lacks a distinct anthocyanin production peak. The practice of bagging brings about the same pattern of physiological change that is critical to color development in Fuji and Jonathan fruit, and the peak anthocyanin production comes immediately before the onset of the ripening process (about 150 days after full bloom of Fuji in Aomori). This is followed by a rapid decline in ability to develop color. Thus, a delay in removing bags before harvest may result in a loss of good red color development.

Effects of Time of Bagging and Bag Removal on Fuji Coloration

Bags are placed onto fruitlets 4 to 6 weeks after petal fall, targeting single fruits, usually king fruit, of selected terminal fruit clusters. Fruit thinning must be finished thoroughly by the time bagging is started. Earlier bagging produces fruit having less chlorophyll concentration that will develop a brilliant red or pink color after removing the bags. This is very important in bagged Mutsu for good coloration but is not so important for Fuji. In bagged Fuji fruits, however, the ability of the fruit to develop red color is likely to decrease more sharply with advance in fruit ripening. The time of bag removal in Fuji might become very important to develop good coloration. Bags are normally removed 4 to 6 weeks before harvest to expose individual fruits to sunlight, allowing them to develop red color.

Bags are removed in two steps. First, only the outer bags are removed to allow acclimation of the fruit to sunlight. The inner bags are removed 4 to 6 days later. When bags are taken off, the fruit skin is pale because double-layer bags shut off sunlight to inhibit chlorophyll production on the skin. After a couple of weeks of exposure, the fruit quickly develops red color. However, if the weather conditions, especially the temperature, are not favorable for color development, Fuji will develop a green color rather than red.

Effects of Bag Differences on Fuji Coloration

Many kinds of bags are used in Japan, depending on the cultivar, grower's preference, and manufacturer's suggestions. Bags used for Fuji usually have double layers. Inner bags without bottoms are made of red, blue or green waxed paper. Outer bags are usually made of light-colored or white paper and are colored black on the inner side to be nearly impervious to light. There is no scientific basis to use specific colors for inner bags. However, bags of deep colors which transmit less light may produce fruit of lower chlorophyll concentration which will affect the coloring behavior of the fruit. As mentioned earlier, bagged Fuji fruits with low chlorophyll concentration sharply decrease in their coloring ability with advance in ripening. These fruit need a longer acclimation time to the sunlight after removing the outer bag.

Effect of Bagging on Eating Quality of Fuji

Bagging reduces soluble solids concentration about 1% (Arakawa et al., 1994). Fruit firmness and acid concentration are not influenced by bagging in Fuji. Bagged Fuji is often said to have longer keeping qualities than nonbagged fruit, but no scientific data are available.

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