NATURAL WAXES ON FRUITS

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Every living organism is packaged in some type of an envelope which serves as the barrier between the organism and its environment. These envelopes consist of polymeric structural components. In land based organisms the envelope is made waterproof with a mixture of fatty materials, collectively called waxes.

THE CUTICLE (Cutin plus Wax)

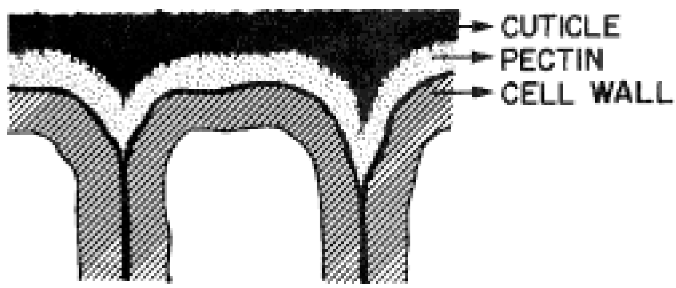


Figure 1. Schematic representation of attachment of the cuticle to the outermost layer of cells of the fruit.

Fruits, like most aerial plant organs, are naturally packaged in an outer envelope called the cuticle. The structural component of the cuticle is a biological polyester called cutin, which is made by the outermost layer of cells called the epidermal cells. Cutin is a large insoluble substance (polymer) made from small molecules which are in turn derived from cellular fat. Since this polymer itself is not a good waterproofing material, the outer envelope is covered with a complex mixture of materials also generated by the epidermal cells from cellular fat. Particles of cutin embedded in wax, make a highly impermeable barrier. The cuticle is attached to the walls of the epidermal cells by a glue layer made from a substance of the cuticle called pectin (Figure 1). The outer surface of the cuticle is relatively flat and smooth, but the underside attached to the plant has ridges which fit into the intercellular gaps to provide a tight attachment. These protrusions can be seen as the cellular outlines in the electron micrograph shown in Figure 2.

WAXY BLOOM (Waxplates vs. Wax Crystals)

Natural wax is also found on the surface of fruits as small crystals which appear as a powdery bloom to the naked eye. Under the high magnification of the electron microscope, which has 100,000 times the resolving capacity of the human eye, the crystalline shape can be clearly seen. Each plant species appears to have its own characteristic crystalline shape and the plate-like crystals found on apple fruit can be readily seen in the electron micrograph shown in Figure 3. Reflection and scattering of lights on the fruit surface by the wax crystals are responsible for the prominent natural waxy bloom found on fruit surfaces.

There is a common misconception that a very shiny fruit surface has more wax than a less shiny one. The presence of wax bloom gives little shine even though the quantity of wax may be quite high. Fruits which show a pronounced natural waxy bloom do not necessarily have more wax than others which show little bloom. For example, plum fruits are no more waxy, but show more

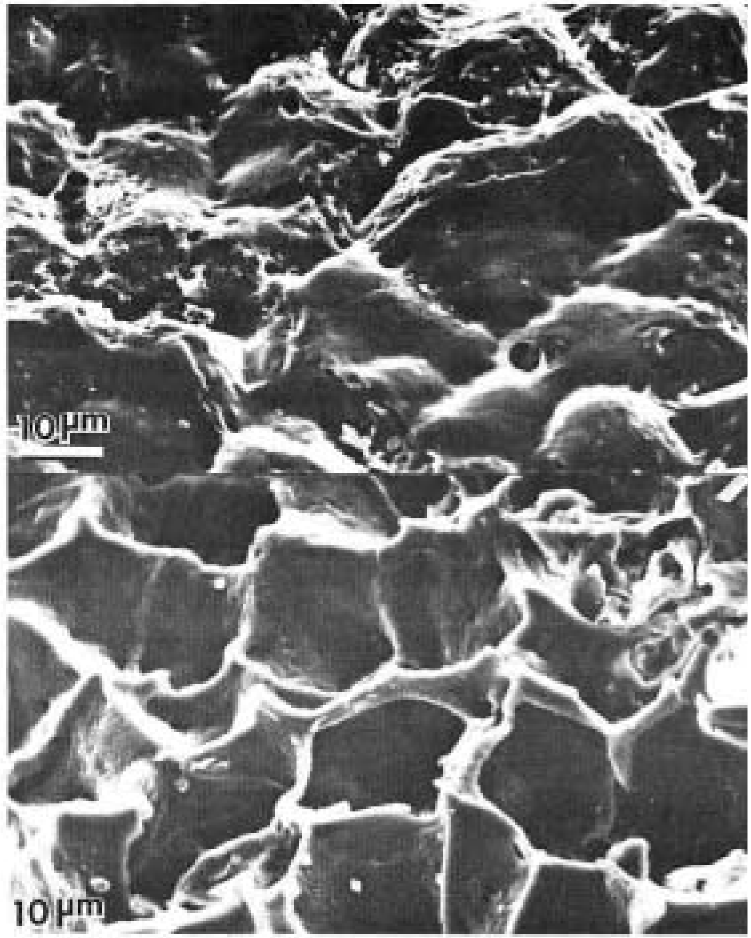
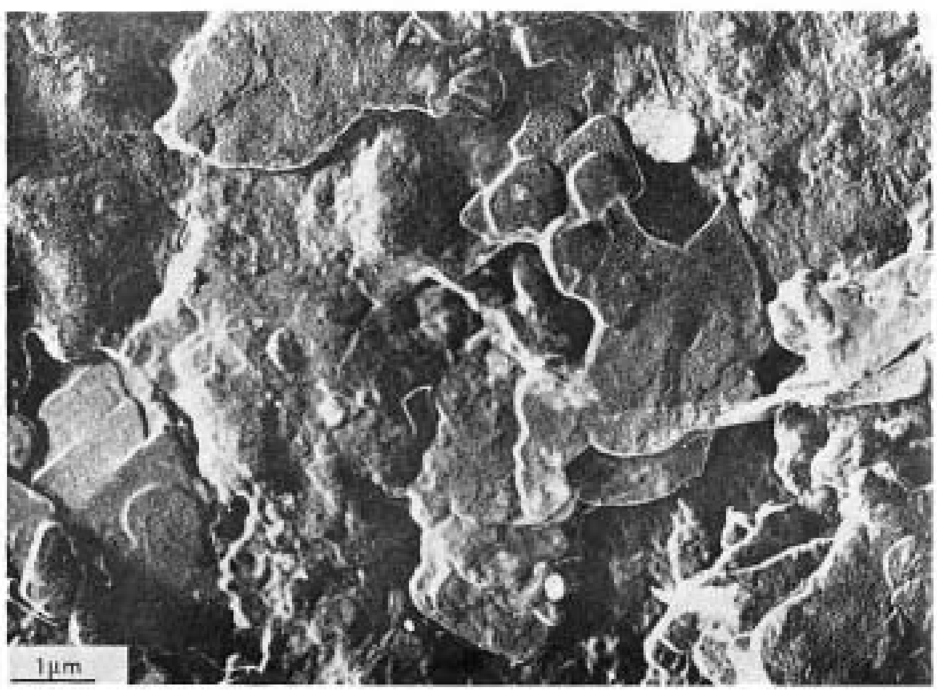


Figure 2. Electron micrograph of the skin polymer, cutin, isolated from apple fruit. Top micrograph shows the outside and bottom micrograph shows the underside of the polymer as it is attached to the fruit.

Figure 3. Electron micrograph of the surface of apple fruit showing the platelet wax crystals.



definite bloom than apple or pear because the fine wax protuberances present on a plum scatter more effectively than the platelets of wax found on apple or pear. Thus it is the physical crystals which play a major role in determining the appearance. The shape of the wax crystals is determined by the chemical composition of the wax. Therefore the appearance of fruit is greatly affected by the chemical composition of the wax on its surface.

COMPOSITION OF NATURAL WAXES

The natural wax on apple fruit contains about fifty individual components belonging to at least half a dozen chemical groups. Two major classes of chemicals are often found. The major cyclic component of apple fruit wax is called ursolic acid and is highly water repellent.

ROLE OF WAX

Wax plays at least two major functions. It provides water repellency to the fruit surface and it reduces water permeability through the skin. Water repellency affects the 'deposition, distribution and retention of chemicals applied to foliage or fruits as solutions or emulsions. Permeability is a major problem when water soluble materials such as calcium need to be introduced into the fruits for desirable effects such as maintenance of firmness.

Waxes prevent moisture loss during fruit storage. Although natural waxes on fruits are effective in preventing water loss, the application of commercial wax can further decrease water loss during prolonged storage. For example, application of the wax formulations to Red Delicious apples by the usual packinghouse operations used in Washington increased the resistance of the fruit surface to water loss and measurably reduced water loss during six-month storage of the fruits (Table 1).

Table 1. Effect of the waxing process used in Washington packinghouses on wax content and water loss of apple fruits.

Treatment	Amount of wax (ppm)	Resistance of fruit surface to water loss (sec/cm)	Water lost in 6 months storage (% of weight)
Untreated	994	293	3.61
Washed	973	--	--
Waxed	978	357	2.78

The data represent the average for five different formulations used on apples harvested from northern, central and southern regions of Washington. Some wax formulations were considerably more effective than others in reducing water loss.

WAX ON GROWING FRUIT

As fruits grow, the amount of natural wax increases in such a way that the quantity present in a unit of area of the fruit surface either shows little change or increases. On apple, for example, the amount of wax per unit area steadily increases as the fruit grows to maturity, whereas on pear the increase in the amount of wax keeps up with the expansion of the surface area of the fruit.

After harvest the quantity and quality of the natural waxes can change. Such changes have been observed during fruit storage. Wax production by plants is known to be greatly influenced by environmental factors. Therefore it is not surprising that storage conditions can affect the post-harvest changes in the amount and composition of wax.

It should be pointed out that there can be large varietal differences in such changes. Some varieties show little change in the quantity and composition of the wax whereas others show considerable changes resulting in significant alterations in the fruit appearance.

COMMERCIAL WAXES

Applying wax formulations to fruits appears to be mainly to improve attractiveness, although some improvement in storage quality has also been noted. The wax formulations used in Washington appear to be based either on carnauba wax or shellac or a mixture of the two. Carnauba wax, all imported from Brazil, is obtained from the leaves of carnauba palm. These leaves produce wax in such abundance that flailing or heating in a little water can yield 5 to 10 grams of wax from each leaf. Shellac, on the other hand, is an insect wax. Both of these natural waxes are complex mixtures of fatty materials and contain some of the same components found in apple wax.

One major difference between natural wax and wax formulations is that the cyclic compound, ursolic acid, which is a major component of apple wax, is not present in either carnauba wax or shellac. There are other less dramatic differences in chemical composition and some of those differences may be quite relevant to providing the desired appearance to fruits.

WAXING PROCESS

The amount of wax applied to fruits appears to be negligible when compared to the natural wax on the fruit. A careful study of the amount of wax added by the commercial waxing process used in the packinghouses in Washington showed that the amount added by the process was so little that the increase over that naturally present was statistically insignificant (Table 1). When reliable analytical methods were used to distinguish between the wax naturally present in the apple and that applied during waxing it was difficult even to detect the presence of the added wax on the waxed apples.

FUTURE RESEARCH

It is possible that the beneficial effects of the waxing process come not only from the waxes that are applied but also from the changes in the natural fruit waxes brought about by the waxing process. Which components present in the complex mixture applied to the fruit are beneficial does not appear to be known. The undesirable changes in the appearance, sometimes observed in the waxed apples in marketing channels, have not been studied from a physical and chemical point of view. There are widespread misconceptions about the fruit waxing, and in the past such misconceptions among consumers and regulatory agencies have caused much confusion. Therefore a systematic study on the waxing problem could yield results helpful in devising the proper waxing process, help the producer, and at the same time alleviate the misconceptions of the consumer.