APPENDIX VI

Technical Facts

BIOLOGICAL AND CHEMICAL NATURE OF COCHINEAL, ITS HOST CACTI, AND RELATED INFORMATION

Biological and Chemical Information On Cochineal

Cochineal is a bright red dye made from the extract of the dried pulverized bodies of the female scale insect Dactylopius confusus of of the Coccidae family (Encyclopaedia Britannica 1974, Vol. 2). This very small insect, which resembles a mealybug, has six legs and thrives by a parasitic relationship with several species of desert cacti (Opuntia and related species) (Encyclopaedia Britannica 1974, Vol. 8), particularly the nopal or Indian fig tree (a plant of the cactus species Nopalea coccinellifera). It can be found in the warmer climates of tropical and subtropical America. Cochineal is especially native to Mexico and Central America (see Figure 1).

The genus Opuntia to which the prickly pear belongs numbers 250 species. It is one of the largest most widespread genera in the family, ranging in North America from Massachusetts to British Columbia, Texas, New Mexico, Arizona; west to California and Baja California, Mexico; in Florida and adjacent coastal states; and southward to the Straits of Magellan. In Texas, the cactus family (cactaceae) can be found in the drier regions of central Texas (not in the east Texas Woodlands). It is commonly found around San Antonio, Corpus Christi, and Brownsville, Texas (Gilbreathe 1985, p. 36; Towle 1961, p. 70).

Dactylopius confusus (scale insect that produces cochineal) is commonly found on prickly pear cactaceae Opuntia sp. and Nopalea (cactacease). Both species of cacti are native to the Americas. The host cacti under cultivation for cochineal were especially the

species Nopalea coccinillifera S. (Goffer 1980, p. 187). Of interest is the fact that prickly pear cacti are not native to Africa. It is believed that the cacti family did not arise until South America and Africa were well separated, 20 or 30 million years ago (Mauseth 1988, p. 305). The opuntia cactus is known to have been transported and established in Peru, the Canary Islands, parts of Australia, Java, and Algeria (Knopf 1980, p. 248).

The chemical substance responsible for producing the red dye of cochineal is primarily carminic acid. Carminic acid is soluble in water, giving a scarlet red solution that turns violet with the addition of alkali. A scarlet color was achieved with 6 percent stannous chloride and 6 percent oxalic acid, added to 20 percent of cochineal (Trotman 1984, p. 376-377). The natural dye, obtained from the cochineal insect, is used to produce the colors; scarlet, crimson, orange and other tints and to prepare a lake (an insoluble coloring compound precipitated from a solution of dye by adding a metallic salt or mordant. The natural dyes have little affinity for vegetable fibers, such as cotton, and have to be treated with a metal compound (usually of aluminum, iron, or tin) to prepare the fiber to receive the dye (Encyclopaedia Britannica 1974, Vol. 5, p. 916-917). Lightfastness can be attributed to the chemical properties of the dye and the metal compound with which it is combined. With a mordant (metal compound) cochineal exhibits good lightfastness. Cochineal is an anthraquinone and this chemical class demonstrates good lightfastness properties (Crews 1986, p. 69).

Cochineal is the potassium salt of carminic acid, a red pigment occurring in the fat-body cells, the eggs and in cells of the larvae of the female cochineal. The anthraquinones (a yellow crystalline ketone found widely in plants but in only a few animals) are acquired by the insects from their plant hosts. No information is available as to how the anthraquinones are metabolized (Encyclopaedia Britannica 1974, Vol. 5, p 916-917). The same or closely allied pigments are found in other scale insects. (Encyclopaedia Britannica 1974, Vol. 5, p. 916). The ability of cochineal to dye is attributed to the presence of the

pigment called cochinealin or carminic acid in the body of the insect. Also present in the cochineal is glycerol myristate (a fat) and coccerin (cochineal wax) (Encyclopaedia Britannica 1974, Vol. 2).

The chemical formula for cochineal is very similar to the formula for kermes, which is also an anthraquinone. Scale insects have value as commercial products. From them, not only is dye derived, but also varnishes and wax. Their value facilitated the chemical investigation of these insect; nevertheless the structural complexity and the difficult chemical nature of these compounds are such that only recently have some definitive results come to light (Brown 1975, p. 268). All known pigments of scale insects are polyketide anthraquinones (Brown 1975, p. 271).

Dyeing with Cochineal

As mentioned, the use of cochineal dye can produce many shades, ranging from orange to purple. The color is changed by the pH of the dyebath, the mordants used, and the fiber. In Appendix III there are a number of recipes for dyeing with cochineal and producing the various shades. There is also a bibliography of books which contain recipes for dyeing with cochineal and other natural dyes.

Ancient Recipe For Dyeing with Cochineal

There are recipes for dyeing with cochineal which were in practice in pre-Columbian times. How long these recipes were in use is not certain, but fabrics found in pre-Inca tombs in Peru have been found to contain cochineal. One of the oldest know recipes for dyeing with cochineal is one still in use by a few Zapotec weavers in village of Teotitlán del Valle, in the valley of Oaxaca, Mexico. This ancient recipe has been presented in Appendix III.

Upon arrival of the Spanish with their citrus trees, Zapotec dyers began using limes as an acidifying agent. Knowledge of the ingredients that were used to acidify the dyebath

before the Spanish brought their lime trees has been lost (Ross 1986, p. 66-72). One ancient ingredient which is still used is acquired by taking a centuries-old route to the lowlands in the Isthmus of Tehuantepec to collect the leaves of the tejute, or hoja lisa tree (Miconia argentea). The recipe calls for the dried bodies of the tiny insects to be ground into a powder and boiled in a water solution with lime juice and dried leaves of the tejute tree. The textile is steeped in this solution until the desired color is achieved. Only a very few Zapotec continue using this age-old recipe, still more dye with cochineal using a modern recipe.

United States Code of Federal Regulation:
Food and Drug Administration
On Cochineal - Alias Carmine, Carminic Acid, and Carmoisine

Color Index Number 75470, NATURAL RED Dye No. 4

Regulatory information about cochineal as an additive to cosmetics, medicine, and food can be found in the Federal Regulations. Cochineal can be found listed under Part 73 - Listing of Color Additives Exempt From Certification; Subpart A - Foods, 73.100 Cochineal extract; carmine; Subpart B - Drugs, 73.1100 cochineal extract, carmine; and Subpart C - Cosmetics, 73.2087 Carmine. The color index for cochineal is Color Index #75470.

When cochineal is used as a colorant for food it is called Red Dye No. 4, and in this form is the aluminum or calcium-aluminum lake or an aluminum hydroxide substrate of the coloring principles, chiefly carminic acid, obtained by an aqueous extraction of the dried cochineal insect. From a conversation with Dr. Arthur Lipman, officer of Direct Additives for the Food and Drug Administration (FDA), I learned that Red Dye No. 3 was about to be banned as a food additive and that it is possible that Red Dye No. 4 will be used in its place. Several years ago, Dole Food Company used Red Dye No. 4 in several of their frozen Hawaiian drinks. This was discontinued and annatto (another natural red dye) was

used in its place. The amount of cochineal used in food is hard to determine, because it is not always listed under Red Dye No. 4. Cochineal certification has not been found necessary by the FDA for the protection of the public health.

Cochineal Imported into the United States

A great quantity of cochineal is imported into the United states annually. In 1988, eight million dollars worth of cochineal come into the United States from Peru in its raw form. Chemical houses in the United States converted the raw cochineal to carmine, carmoisine, or carminic acid. Many chemical supply company catalogues list cochineal for sale under the name carminic acid, carmoisine, carminosin, or cochineal. I have ordered both carmine and cochineal from Janssen and found that both of these products came from Belgium. A bottle of red food coloring obtained from England lists one of the ingredients as carmoisine.