ift BASIC SYMPOSIUM SERIES

Natural Food Colorants

Science and Technology

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Science and Technology

edited by

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Preface

Responding to its membership, the Institute of Food Technologists' Continuing Education Committee sponsored a Basic Symposium on Natural Colorants on July 23 and 24, 1999. Together, the editors, as co-chairs, selected and coordinated the speakers, conducted the 2-day symposium, and assembled the manuscripts for this book. It was a labor of love.

Seventeen internationally renowned scientists and managers came together in Chicago to review and update scientific information relative to natural colorants. The topic was not only appropriate but timely, reflecting the increased consumer demand for "all-natural" products, which encourages the use of natural colorants. It was the aim of the symposium to improve, correct, and update the current knowledge base by covering all aspects of natural colorants from their chemistry, preparation, formulation, application, and measurement to safety, regulatory, and health considerations.

The chromophores reviewed were selected on the basis of commercial usage, availability, and potential future usage. Omitted were pigments that are rare, have limited distribution, or have a low probability of obtaining regulatory acceptance in both the United States and the European Union.

We would like to thank all of the speakers for their participation, and especially for preparation and submission of a chapter for this book, thus making available a permanent record of this historic event for those who could not attend and for the generation of scientists to follow. Unfortunately, two speakers, John Hallagan and Joseph F. Borzelleca, because of the press of current assignments, could not complete their chapters in time to meet the publication deadline. Abstracts of their talks are presented below.

Regulations in the United States (John Hallagan, IACM, Washington, DC): In the United States, color additives are regulated under the authority of the 1960 Color Additives Amendments to the Federal Food, Drug, and Cosmetic Act, which provides for the establishment of the pre-market approval program currently administered by the Food & Drug Administration. FDA regulates color additives as members of one of two classes of materials, "certified" color additives or color additives "exempt from certification." These two classes generally correspond to "synthetic" (certified) and "natural" (exempt) color additives. Both classes of color additives are subject to the same safety requirements. Different regulations govern the labeling of foods containing the two classes of color additives, with more specific disclosure required for certified color additives.

Determination of Safety (Joseph F. Borzelleca, Virginia Commonwealth University, Richmond, VA): The safety evaluation (SE) of food ingredients is an essential component of premarketing research and development and usually follows the demonstration of functionality. The extent of SE testing is a function of the chemical and/or physical nature of the ingredient and the extent of exposure (and appropriate regulations). Potentially sensitive segments of the consuming population are identified, and appropriate evaluations are conducted. SE testing in humans is highly desirable and should be conducted as soon as the animal data support it. For new macroingredients, postmarketing surveillance is recommended. The need for extensive animal testing may be modified by data documenting human exposure. A long history of safe use may support the safety of an ingredient but historical data alone are not an adequate basis for documenting safety. The extent of nonhuman data required to establish safe limits of human exposure will be determined by the quality and quantity of the available and properly documented human exposure data. For natural (noncertifiable) colors, the extent of animal testing should be less than that required for synthetic (certifiable) colors. A summary of the available SE data in animals and in humans for selected natural colors is presented and evaluated.

This book should extend the horizons of those using natural colorants for years to come.

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Carmine

José Schul

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> Anyone wishing to gain insight into aspects of the commercial exploitation of products derived from cochineal for food and beverage uses, should be prepared to enter a field embracing not only the physical, chemical and biological sciences, but also a range of other disciplines including archaeology, economics, geography, history, linguistics and even visual arts. No short paper could hope to do justice to this intricate and fascinating subject (Lloyd, 1979).

Cochineal is an extremely important product for the Peruvian economy, not just in the commercial value of the material itself but also for the jobs that it creates. As a consequence, the Peruvian Society of Natural Colors has been conducting extensive research on improving all facets of the cochineal-producing industry.

EARLY USE OF NATURAL COLORANTS

Colors have played a very important role in the history of humankind. Think about the surprising colors of the paintings found in the caverns of Altamira (Spain), Lascaux (France), and elsewhere around the world.

For colorants, early humans turned to nature. In the wrappings of a mummy dated around 3200 B.C. three colorants were found: two ochres and safflower yellow. A cloth from Theba, 3000 B.C. was found to be dyed with indigo (Schweppe, 1992).

The use of certain colors became symbolic due to the rarity and expense of their natural sources. In 1464, Pope Paul II introduced the red robes for Cardinals as a symbol of distinction. In oriental kingdoms only the rulers wore purple. Julius Caesar, after rising to full power, reserved for himself the right to wear purple robes. His highest officials were allowed to wear purple stripes. This tradition can still be seen today in the form of purple stripes on the trousers of some generals (Schweppe, 1992).

If you visit the Art Museum of Lima you may see woolen cloth from the Paracas Culture (1100 B.C.). These fabrics were colored with cochineal extract and look as if they could have been dyed and woven yesterday. Cochineal extract is one of the few organic colorants that resists degradation with time.

GENERAL INFORMATION

Cochineal red is extracted from the wingless female scale insect variously called cochineal, *Dactylopius coccus*, coccus Cacti, or *Dactilopius coccus* L. Costa. It is a parasitic insect whose host plants are cacti, principally the Opuntia and Nopalea. The dried insect bodies contain up to 24% carminic acid, a red hydroxyanthraquinone dye. The high concentration of carminic acid in the insect is a defense against predators that do not like the smell or taste.

Cochineal is not the only insect to contain colorants. Others include kermes (*Kermes vermilio*), Polish cochineal (*Porphirophora polonica*), and lac (*Kerria lacca*). Until the discovery of cochineal in the New World, Kermes, which is mentioned several times in the Old and New Testaments, was the most important of all red dyes. Kermes, however, contains much less colorant and gives a red shade that is less pure than cochineal.

HISTORICAL EVENTS

The story begins in 1512 with the Spanish conquest of Mexico. The Spaniards found the Aztecs using the extract of an insect called "Nochetzli" as a paint and as a dye. The Spaniards recognized the similarity to kermes and immediately recognized its commercial value.

Export to the Spanish court began in 1523, and cochineal became a very "hot" item. After New World gold and silver, it was the most valuable commodity.

Because the microscope had not yet been invented, Europeans believed that the dried insects were red berries. The Spaniards were not eager to correct the misunderstanding, and cochineal's insect origins remained a trade secret. Eventually, in 1694 Nicolaas Hartsocker, a lens, microscope, and telescope manufacturer living near Paris, demonstrated that cochineal was actually the dried body of a female insect filled with red eggs (Schweppe, 1992).

In 1785, Thiery de Menonville took cochineal from Oaxaca to Port au Prince, Haiti. He wrote a book about his adventures and a treatise on the cultivation of Nopalea and the coccus Cacti. Menonville tried to convince the French colonial authorities to introduce, particularly to Santo Domingo, the cultivation of the plant and the insect. Unsuccessful, he died in 1790.

In 1835, cochineal was introduced to the Canary Islands, where it is still cultivated. Soon European markets contained cochineal from a variety of sources: Honduras, Vera-Cruz, the Canary Islands, Java, and perhaps others. Many of the original types have since disappeared.

Up until the second half of the nineteenth century, the brilliant red of wool or cotton dyed with cochineal was impossible to obtain with any other dye. The development of synthetic dyes in 1856 resulted in a decline in the use of cochineal. Synthetics proved to be much less expensive, more consistently available, and offered a wide range of bright, attractive shades.

The 1970s and 1980s were difficult times for U.S. manufacturers and users of synthetic food colors. Food color regulations mandated that colorants could not be permitted if they "induced cancer in man or animal when fed at any level" (Food, Drug and Cosmetic Act, 1960). FDA interpreted this as a requirement that colors be tested to prove zero risk. Soon the colors were being used as a proving ground for new toxicology methods.

In 1976 FD&C Red #2 was "delisted" by FDA "out of concern for the public concern." The safety of Red #40 was successfully defended by industry but not before alarming the marketplace. When questions began to arise concerning the safety of FD&C Red #3, the industry was left with few options.

If FD&C Red #3 were banned, the only remaining synthetic red would be FD&C Red #40, and it was often not an acceptable replacement. The two colors were significantly different both in shade and in chemical properties.

The marketplace was changing too. U.S. food manufacturers were looking at export markets, the majority of which did not permit FD&C Red #40 at that time. There was a need for a universally permitted red colorant that was stable and attractive.

In anticipation of a potential FDA ban on Red #3, there was a resurgence of interest in cochineal-based colorants. Traditionally used as a cosmetic color in the United States, cochineal-based colorants could provide bright, attractive red shades similar to Red #3. The color was extremely stable to heat and light. Cochineal-based colorants were sensitive to low pH, but so was Red #3. Finally, almost every country in the world permitted it for food use.

In 1990 when FDA did eventually "delist" FD&C Red #3 (and the provisionally approved uses of the dye) [21 CFR §81.10(u)], the industry had already elected cochineal-based colorants as some of the best replacements.

But the food industry, accustomed to synthetic colors, asked for quality controls to which the carmine manufacturers were not accustomed. The manufacturing methods were old fashioned, the official control methods were out of date, and the published literature nonexistent. It was a challenge to adopt the requirements and to develop new colorants based on cochineal.

But the industry *did* react, and today many cochineal-based colorants are available for food use. These colors are no longer seen as simple replacements for synthetic dyes, but rather are selected for their own unique properties and shades.

One problem continued to limit the use of cochineal-based colorants in the United States—the lack of kosher certification. The author's company, Warner-Jenkinson, has recently been able to obtain Kosher certification through several Rabbinical authorities. Opinions vary on this issue, and a specific rabbinical service may or may not accept these certifications.

U.S. REGULATORY STATUS

Cochineal extract and carmine are regulated by FDA in 21CFR 73.100. This section in the Code of Federal Regulations provides definitions, chemical specifications, and allowable applications.

LIFE CYCLE AND PROPAGATION

Cochineal is an insect and a parasite that lives anchored on cactus leaves. The male has two small wings and the female none. The female attaches herself to the green part of the cactus leaf with her mouth and feeds on the nutritious juice. For protection from the weather, the female covers her body with a white waxy substance.

The propagation method is to put the female insects, which are ready to lay their eggs, in small, open-meshed fabric bags. The bags are fixed onto the cactus leaves using the plant's thorns. The infestation epoch in the *sierra* (the mountains) is during the months of April to October and in the spring on the *costa* (the coast).