The Color of Honey

A sweetener that bee-devils food spoilage

By JANET RALOFF

Honey comes in varying shades—from almost colorless to deep amber to darker than molasses—reflecting the particular nectars that bees harvested to make this natural sweetener.

National Honey Board

Many people—including a number of nutritionists—"dismiss honey as nothing more than sugar water," says May R. Berenbaum. "Biologically, however, that makes no sense."

A concentrated form of nectar, honey is the principal source of nutrition for adult bees, observes Berenbaum, an entomologist at the University of Illinois at Urbana-Champaign. Mixed with pollen, it also serves as the dietary staple of bee larvae. Indeed, honey supplies the insects with a wealth of vitamins, minerals, and other plant-derived nutrients.

Chemical analyses by Berenbaum's team now show that some honeys also possess surprising quantities of antioxidants—non-nutritive agents that can retard biologically destructive chemical reactions that cause rancidity in foods and that have been linked to many chronic diseases. When honey is cooked, it appears to acquire additional, functionally important antioxidants, according to related studies now under way at Clemson (S.C.) University.

These new data suggest that substituting honey for refined sugar in foods might provide health and storage benefits. Honey also offers a natural source of antioxidants to manufacturers of skin-care products such as sunscreens.

All of this sounds mighty sweet to the United States' beleaguered beekeepers. As their hives have succumbed to blights, the cost of honey production has skyrocketed (SN: 8/8/98, p. 84). At the same time, foreign honey has flooded the U.S. market, keeping the commodity's wholesale price relatively low.

If findings from the antioxidant studies are confirmed, U.S. producers may see substantially greater demand—and prices—for their honey, especially the darker varieties that have often been considered second-rate.

The low status of one honey provided a major impetus for the Urbana studies.

The state of Illinois issues grants for research into ways of increasing the value of existing crops and commodities. "Soybean honey, which is what a lot of Illinois beekeepers produce, is not highly prized," Berenbaum notes. It tends to be darker than honeys from bees foraging on clover or orange blossoms, and it lacks their fruity taste. "It has no cachet," she adds, which may explain why this sweetener is usually labeled as deriving from wildflowers, which the bees also visit.

Although honey has been used as a folk remedy for burns, cataracts, ulcers, and wounds—all conditions in which oxidation can play a role—no one had systematically surveyed different honeys to determine whether the antioxidant capacity varies with the nectar source, the Illinois team observes, or even whether antioxidant concentrations in honey are sufficiently high to be of biological significance.

So Berenbaum's group assayed 19 honeys from bees in widely varying geographic locations: Hawaii, Florida, Arizona, Illinois, California, and Washington State. The syrupy sweeteners represented 14 different primary floral nectars—from fireweed and mesquite to star thistle and sunflowers.

The activity of all water-soluble antioxidants in each honey was compared to that of ascorbic acid, or vitamin C—the gold standard. Because one molecule of ascorbic acid can neutralize two molecules of an oxidant, a micromole of vitamin C is defined as having a potency of 2 microequivalents (μeq).

In the summer JOURNAL OF APICULTURAL RESEARCH, Berenbaum and her Illinois colleagues Steven M. Frankel and Gene E. Robinson report finding a clear trend. Although honeys vary widely in the quantity of water-soluble antioxidants

they contain, the scientists found that the darker a honey's color, the higher its antioxidant activity.

A milliliter of Illinois buckwheat honey, by far the darkest tested, contained 4.32 x 10^{-3} μeq, which is 20 times the antioxidant activity in the same quantity of California sage honey, one of the lightest-colored samples. Sunflower, christmasberry, and water-tupelo honeys, also at the dark end of the color range, were the next richest sources of antioxidants, although their antioxidant content was only 25 to 40 percent as high. Soybean and clover honeys, which fall in the middle of the color range, had only 10 to 12 percent of buckwheat's antioxidant potential.

A few honeys buck the trend, however. Though fairly light, sweet-clover honey is antioxidant-rich, while a darkly golden mesquite version possesses relatively little antioxidant activity. Overall, however, the analysis concludes that color predicts more than 60 percent of the variation in a honey's antioxidant capacity.

While the Illinois scientists did not identify the antioxidants in any given honey, previous studies have shown that nectar tends to contain large quantities of flavonoids—plant pigments and flavoring compounds with antioxidant properties. "My guess is that these flavonoids are not only contributing to the honey's antioxidant activity but are probably the principle contributors," Berenbaum told SCIENCE NEWS.

Most fruits and vegetables contain antioxidants. Though the average honey's ascorbic-acid equivalency, 0.8 x 10^{-3} μeq per milligram, comes close to that of tomatoes, Berenbaum's group notes that many fruits and vegetables possess far more. Orange pulp, for instance, has 5.7 x 10^{-3} μeq/mg, and broccoli and sweet peppers show 13.0 x 10^{-3} μeq/mg. Dried tea, renowned for its antioxidants, can run to 220 x 10^{-3} μeq/mg.

Moreover, Berenbaum is quick to point out, these figures may actually underestimate those foods' oxidant-quashing activity, since many of them—unlike honey—also contain large quantities of fat-soluble antioxidants such as vitamin E and carotenoids. People also tend to eat far smaller quantities of honey than they do most fruits and vegetables.

Still, she notes, per capita sugar consumption in the United States "is enormous"—roughly 150 pounds per year, according to the latest Department of Agriculture statistics. "If you were to substitute honey for all that sugar," she surmises, "the contribution of its antioxidants might become substantial."

Although the presence of antioxidants suggests that honey might be able to limit the ravages of biologically destructive agents, the proof is in the pudding, or muffins, or sausage, notes Nicki J. Engeseth, a food scientist at the University of Illinois.

In one set of experiments, she therefore added honey to fruits and vegetables that turn brown upon exposure to air. In such foods, an enzyme in the plant tissues triggers a reaction between oxygen and phenolic chemicals. The resulting browning not only makes the food unappealing but also uses up its vitamin C.

For this test, she put freshly cut apples, pears, potatoes, or yams into a blender—grinding them into a soupy homogenate—then mixed in one of six different types of honey. Though the light colored acacia honey offered no protection against browning, the darker honeys did.

Christmasberry honey retarded the browning enzyme's activity by up to 50 percent, for example. While the honey didn't match the potency of ascorbic acid or sulfites—two commercially popular antioxidants—it did lengthen the time before browning occurred.

Soy honey also greatly reduced the rate at which the foods turned brown. Indeed, it proved far more effective than the clover honeys, even though all possessed similar antioxidant ratings. This suggests, Engeseth says, that for certain applications, which antioxidants are present may be as important as their quantity.

Though buckwheat honey's high antioxidant content suggested it probably would have had the best chance of retarding enzymatic browning, "we couldn't use it," Engeseth says, because its "tarry" color would have darkened foods even in the absence of any oxidation.

In a second experiment, the group investigated honey's ability to slow the oxidation of fats. A form of food spoilage, this process turns fats rancid (SN: 2/9/85, p. 88) and may transform them into a potent risk factor for artery-clogging heart disease (SN: 5/4/85, p. 278).

In this test, the food scientists added honey to ground turkey, making the sweetener 5 percent of the total weight. "We picked poultry," she notes, "because honey is already used in a number of recipes such as honey-smoked turkey." Because lipid oxidation accelerates dramatically once a meat is heated, the Illinois team panfried the concoction.

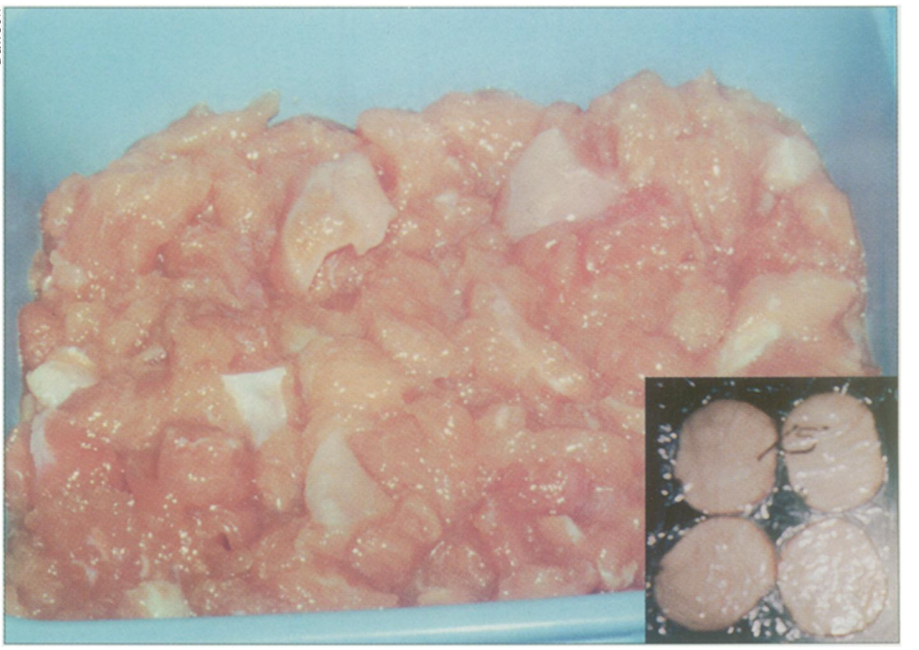
Three days later, they assayed the meat for oxidation products. Compared to unhoneyed poultry that had been similarly cooked and refrigerated, the honeyed meats exhibited far less rancidity. Again, the darker honeys performed best. Buckwheat honey, permitted in this test, cut oxidation by 70 percent, roughly twice as much as the light-colored acacia honey did. The amount of honey added to the meat was not enough to make it taste sweet, Engeseth notes.

The researchers presented preliminary findings from both studies in June at the Institute of Food Technologists annual meeting in Atlanta.

At the same meeting, Paul Dawson's team from Clemson presented data on an alternative use of honey—not as a source of antioxidants but as a raw ingredient in their production.

While some foods brown upon exposure to air through a series of enzyme-driven reactions, others brown in cooking via a heat-activated transformation of sugars. Known as a Maillard reaction, this browning causes bread crusts to turn golden, the surface of broiled meats to become dark and crispy, and the tops of custards to caramelize. In moderation, the browning enhances both the appear-

Dawson



Clemson food scientists added honey to a batter, mixed in poultry pieces, then baked it into a restructured-turkey loaf. Vacuum-packed slices of the finished product (inset) could be sold as a long-shelf-life lunch meat at grocery deli counters, they suggest.

ance and flavor of foods.

"Another byproduct of this Maillard reaction is the creation of antioxidant compounds," notes Dawson. Because extra sugar can foster the reaction, his group mixed a large amount of honey into the batter that binds small pieces of turkey into a restructured turkey roll. The honey made up 15 percent by weight of the ingredients but did not impart a sweet flavor to the finished product.

When they assayed the rate of oxidation in slices of the cooked meat after 2 days of refrigeration, the honeyed turkey exhibited only 15 percent as much fat oxidation as the untreated meat.

These data indicate that adding honey "probably would extend the shelf life of such deli-type products by several weeks to a month," Dawson says. Moreover, the honey treatment also appeared to reduce bacterial growth in the product. "We're not sure why," Dawson says, though it may reflect the sweetener's ability to tie up water—as sugars do in jam—rendering it unavailable to microbes.

Though the Clemson studies have focused on techniques likely to aid commercial food processors, Dawson notes that some of the findings might offer ideas to home cooks interested in extending the life of their leftovers. For instance, applying a honey glaze to a roast may retard the oxidation of the uncut meat. Similarly, adding honey to recipes for sausage, meat loaves, and other entrees that include ground meat should retard the rate at which rancid off-flavors develop, he says.

Antioxidant-rich honeys may also find a role in skin-care products, according to David Ropa of Thomas J. Payne Market Development. The Chicago-based consultant prepared a study last year for the National Honey Board in Longmont, Colo.

Honey "can be used to produce alpha hydroxy acids (AHAs), a vital ingredient in the growing market for skin creams and moisturizers," he says. Indeed, manufacturers are currently developing commercial methods to make honey-derived AHAs. The AHAs work, Ropa explains, "by exfoliating the skin and increasing the rate of cell renewal."

Several manufacturers already tap honey in the preparation of moisturizers. Honey "retains moisture and resembles the skin's natural moisturizing factor," notes David Chin, manager of technical marketing in the Somerville, N.J., office of Laboratoires Serobiologiques. Indeed, he says, that's why the French company has used a honey extract in one of its moisturizers for more than 20 years.

Because antioxidants can protect key components of the skin's cells from damage, many firms now add antioxidants to their products, especially sunscreens, Ropa reports. "If honey can act as both an antioxidant and a moisturizer in sunscreens and other skin-care products," he told SCIENCE NEWS, "the potential for this natural ingredient is enormous."

Though Laboratoires Serobiologiques employs antioxidants in many of its products, it has never considered honey as a possible source, Chin says. If, however, manufacturers can look to this natural product for both moisturizing and antioxidant functions, he told SCIENCE NEWS, "demand for honey could go flying out of sight—just like a bee." □

Biomedicine

Drug smokers have precancerous signs

Regular smoking of marijuana or crack cocaine produces changes in the lungs that appear to be precursors of cancer, scientists at the University of California, Los Angeles find.

To assess these effects, the researchers took lung biopsies of 104 healthy adults—81 men and 23 women. The group included 28 nonsmokers, 12 who smoked marijuana only, 13 who smoked crack cocaine only, 14 tobacco-only smokers, and 37 who smoked combinations of two or three of these substances.

The scientists then examined the biopsied lung tissues for several proteins that can indicate a heightened cancer risk. These included the p53 protein—a known cancer fighter normally produced in response to the disease—and two others, Ki-67 and epidermal growth factor receptor (EGFR), that play a role in cell proliferation. They also looked for tissue-growth abnormalities at the cellular level, including overproduction of cells in the lung lining and DNA variations.

Few nonsmokers displayed any of the high-risk signs. However, 8 of the 10 cellular abnormalities studied showed up in at least half of the marijuana-only smokers, who had smoked an average of 10 or more joints a week for 5 years. Those who used both marijuana and tobacco registered even more abnormalities. Also, 11 of the 12 marijuana-only smokers had Ki-67 protein in their lungs, and 7 had EGFR, the researchers report in the Aug. 19 JOURNAL OF THE NATIONAL CANCER INSTITUTE.

The crack cocaine smokers, who had used the substance for at least 9 months, showed similarly high levels of Ki-67 and EGFR but had widely varying evidence of cellular abnormalities. The p53 protein, usually seen only in cancer patients, showed up only in some smokers who combined substances.

Although the abnormalities measured don't necessarily lead to cancer, lung cancer patients virtually always have them, says study coauthor Donald P. Tashkin, a pulmonologist at UCLA.

Of the cellular abnormalities, he notes, "the most serious involve nuclear variations that increase the cells' replication rate." All 7 people who smoked both marijuana and tobacco had these variations, as did 6 of the 12 marijuana-only smokers. —*N.S.*

Two embryos are better than three

Although in vitro fertilization (IVF) helps thousands of infertile couples to have children, it also yields multiple births roughly a fourth of the time. In the procedure, doctors typically take eggs from a woman's ovaries, fertilize them with sperm in a laboratory, then place them in the woman's uterus. IVF results in pregnancy in about one in five tries.

Multiple births, which occur in less than 2 percent of unassisted pregnancies, arise more often from IVF because doctors transfer several fertilized eggs, or embryos, to improve the odds. The United Kingdom restricts the number of embryos transferred to three at a time; the United States imposes no limits.

Seeking a way to limit multiple births, scientists in Scotland reviewed data from 25,240 women who had undergone IVF. The researchers report in the Aug. 27 NEW ENGLAND JOURNAL OF MEDICINE that when more than four eggs were fertilized but only the two most robust-looking embryos were chosen, pregnancy resulted at the same rate as when women received three or more embryos. Moreover, women receiving two embryos instead of three had many fewer multiple births.

Fertilizing a greater number of embryos enables the doctors to have more selectivity, says coauthor Allan Templeton, an obstetric gynecologist at Aberdeen University. The best embryos, he says, "look nice and round and are dividing at a good rate."

"Clearly, there is pressure from patients to maximize the chances" of a successful pregnancy by using more embryos, Templeton says. "In the U.K., there's an increasing perception that in most circumstances putting back [into the woman] lots of embryos doesn't achieve very much." —*N.S.*