



New Cuisine Wins Rave Reviews From Honey Bees

Honey bee hives from Maine to California are abuzz with news about a new food that originated from a chance conversation between two ARS scientists. At an Entomological Society of America meeting in the summer of 2001, entomologists Gloria DeGrandi-Hoffman, who specializes in honey bee research, and Allen C. Cohen, who is internationally recognized for his pioneering work with foods for insects, met and discussed a problem that has plagued California's almond growers for years.

These orchardists, producers of the nation's \$1 billion almond crop, need bustling colonies of honey bees—alive with strong workers and healthy young, known as brood—to pollinate their vast orchards during the winter months. That's the time of year these trees begin to flower. But it's also when bees are in a near-hibernating state and not being very industrious.

Cohen and DeGrandi-Hoffman, now research leader at the ARS Carl Hayden Bee Research Center, Tuscon, Arizona, decided to collaborate in developing a recipe for an artificial diet that would give honey bees the whole package of nutrients they need in an easily digestible liquid. This would keep the bees rearing brood and ready to work once the almond blossoms appear.

Presently, beekeepers use soy patties to feed bees during winter, before almond blossoms—floral treasure troves of

pollen and nectar—are readily available. The major problem with these patties is that they are costly and labor-intensive. Beekeepers must either go from hive to hive and manually insert the patties or place large tubs of the dry patty mix near their beehives.

The patties—typically made of corn syrup, soy flour, and brewer's yeast—create another problem. For reasons not yet understood, bees that eat soy patties eventually lose their ability to produce a food, called worker jelly, that's vital for the brood.

With a liquid diet, a machine already used by beekeepers would be able to easily pump the bee food into the hives, a far less labor-intensive approach, says Cohen. He recently retired from the ARS Biological Control and Mass Rearing Research Unit in Mississippi State, Mississippi. In the late 1980s, he was stationed at the Bee Research Center and worked with DeGrandi-Hoffman there.

Cohen started with an existing diet that he created for indoor rearing of lygus bugs. It was patented by USDA in 2000. To meet the needs of beekeepers, he converted the lygus bug food from solid to liquid, blending ingredients that provide vital nutrients.

Cohen wanted to create a formula that would combine the sweetness of nectar and the nutritional punch of pollen into a digestible, absorbable food that bees would gobble up.

Honey bees devour a new, nutrient-rich food. This artificial diet resulted from 5 months of research. Photo by Stephen Ausmus. (K10288-1)



Nectar is rich in carbohydrates. Pollen is packed with protein, vitamins, minerals, fats, and perhaps as-yet-undiscovered compounds essential for bees' survival.

"What we didn't know is whether bees would be able to take a liquid that combined the qualities of both nectar and pollen and process it in such a way that the formula would be completely nutritious for them," says Cohen. "That was really

one of the most exciting possibilities—to see whether we could essentially fool the bees' natural digestive mechanisms."

Cohen's classic recipe, modified slightly, thus became the Arizona lab's starting point for a new menu option for domesticated honey bees, *Apis mellifera*.

With Cohen's formula in hand, DeGrandi-Hoffman and Gordon I. Wardell, an entomologist and corporate collaborator at Tucson, mixed batches of the creamy-white liquid for bees to taste-test.

The intent was to create an elixir so delectable that adult bees would not only eagerly eat it but would also, as is their usual practice, store some of it in the hive for nurse bees—the hive's round-the-clock nannies—to feed to the colony's brood.

For the investigations, Wardell assembled 12 small hives, then enclosed them with netting so bees couldn't sneak out during the tests to bring their familiar foods back to the hive. Each hive housed about 3,500 to 4,000 bees. "We offered the bees one kind of food—either sugar-water, pollen, or the new liquid, which we poured into petri dishes," says Wardell. The bees ate little, if any, of the new concoction.

STEPHEN AUSMUS (K10285-1)



Entomologists Gloria DeGrandi-Hoffman (right) and Gordon Wardell observe comparison feeding trials in which different diets are offered and bee preference is monitored.



Gordon Wardell prepares a variation of Allen Cohen's classic recipe, a scrumptious blend of vital nutrients that finicky bees just can't resist.

To make it more appetizing, the researchers launched a series of new experiments, presenting variations of the baseline recipe for the bees' approval. The scientists structured these experiments so that despite natural variations from one six-legged taste-tester to the next, the findings would be statistically sound.

After 5 months and nearly 80 reformulations, the team hit on an apparently scrumptious creation that the finicky bees just couldn't resist. The scientists then tested it in full-size hives, each accommodating about 30,000 bees. Wardell and co-worker Fabiana Ahumada-Segura fitted each hive with a small window so that they could spy on the dining bees.

"At one point," says Wardell, "we saw 75 to 100 bees jammed around a petri dish, pushing and shoving each other to get to the food. In the commotion, some of the bees fell into the petri dish. It was like a bee mud-wrestling match."

Adds Cohen, "This is somewhat historic because people have tried for the past 50 years to develop diets for bees but were unable to get the bees to continue to rear brood on those formulas. With the new diet, bees have been able to rear continuous generations of brood."

To see whether the new culinary offering would please bees elsewhere, Wardell sent samples to commercial beekeepers in Arizona, California, Georgia, Maine, Michigan, New Mexico, and Pennsylvania. "All the beekeepers reported that their bees liked this recipe," Wardell says. "One beekeeper asked an assistant to take a ruler out to a hive and measure how much food was left after the bees had about 4 hours to try it out. To their

amazement, all the food was gone."

More work is needed, however, before the experimental food is ready for commercial and hobbyist beekeepers to use. "We want to cut the cost so the food is affordable," Wardell explains. "We're using very pure, pricey ingredients, but we intend to substitute less-expensive compounds." The scientists also aim to develop a dry mix. Lighter than the liquid, it should be cheaper to ship.

Further fine-tuning of the formula may boost brood survival rates and lengthen adult bees' typical 4-week life-span. Currently, both these measures are about the same among bees reared on pollen patties and those fed the novel food.

Another planned upgrade: compounds known as feeding stimulants that may entice bees to eat even more. Though these are already standard ingredients in other foods formulated for nourishing beneficial insects, apparently no one yet knows which feeding stimulants would appeal to honey bees.

The researchers intend to seek a patent for their bee cuisine.—By **Alfredo Flores** and **Marcia Wood**, ARS.

This research is part of Crop Protection and Quarantine (#304) and Crop Production (#305), two ARS National Programs described on the World Wide Web at www.nps.ars.usda.gov.

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