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Retraining Food Cravings, Choices

Story begins on page 8

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Agricultural Research

Solving Problems for the Growing World

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PEGGY GREB (K10410-1)

March is national nutrition month. If you are looking to manage your weight, read our nutrition story in this issue. New findings indicate that it is possible to change the cycle of constantly craving unhealthy foods by retraining the brain to stop activating its reward centers on exposure to a steady stream of high-calorie foods and food cues. Story begins on page 8.

3 Aerial Imaging Spots Problems in Cotton Fields

4 Sniffing Out Overwintering Stink Bugs

6 Wheat Varieties Make Way to Breads and Malt Beverages

7 Novel Vaccines Effective Against Poultry Diseases

8 Shifting Out of High-Calorie Habits

10 Yeast and Sugar Lure Pest to Beneficial Virus

Cover: Most of us like high-calorie foods from time to time, but it's easy to get into the habit of wanting those foods all too often. New findings indicate that it is possible to change the cycle of craving these foods by retraining the brain to respond favorably to selections, like this beautiful salad, that could be better for our waistline. Story begins on page 8. Photo by Peggy Greb. (D2271-3)

Aerial Imaging Spots Problems in Cotton Fields

CHENGHAI YANG (D3385-1)

Agricultural engineer Chenghai Yang (left) discusses image acquisition plans for a two-camera imaging system with technician Fred Gomez (center) and pilot Lee Denham. All three are with ARS.

CHENGHAI YANG (D3386-1)

Aerial color-infrared image of a cotton field. Areas infected with cotton root rot are greenish.

Many cotton fields are too big to survey on foot to yield timely information about the health of the crop. Specific areas, for instance, may need treatment for diseases, weeds, irrigation, or applications that enhance plant growth.

Chenghai Yang, an agricultural engineer with the Agricultural Research Service's Aerial Application Technology Research Unit in College Station, Texas, has developed an imaging system to help growers get that information: Digital images are taken from aircraft and are detailed enough to show patches of large fields in need of special attention.

Small aircraft have been used for years to survey fields and treat crops for pests, diseases, and other problems. Yang, working with Texas A&M AgriLife scientists, began evaluating whether aerial imagery could spot specific problem sites in cotton fields when, a few years ago, growers started using a new fungicide for cotton root rot control. Root rot infections are usually limited to 20 to 30 percent of a field. Ideally, growers should identify infected areas near the end of one growing season so they could apply the fungicide to just the areas that are infected at the start of the next season. But instead, many routinely treat entire 200-acre fields, wasting a fungicide that costs about $50 an acre, says Yang.

"If you're treating 100 acres unnecessarily, at $50 an acre, you're wasting $5,000, and some growers do that every year because there is no easy way to detect infection sites," he says.

Yang and his colleagues mounted two digital cameras on the underside of a small airplane, equipped them with GPS, and took images of cotton fields to see whether they could identify areas with cotton root rot. They also evaluated whether the cameras could identify the widths of cotton rows—a key indicator of plant height. One camera took standard color images. The other was filtered to shoot in near-infrared, which is often used in aerial imagery because of its effectiveness at detecting plant stress. Yang tested the system for 2 years in about 40 flights on both sunny and cloudy days.

Yang's published results show that aerial imagery could detect the presence, location, and disease progression of cotton root rot. The team showed that cameras could be used to detect weeds and invasive plants and identify areas affected by drought stress.

The efforts mean that agricultural pilots have a new service: aerial surveys that help growers identify diseases, pests, and other problems in specific areas. The dual-camera system used in the studies costs about $6,000. But Yang says that a $1,500 system, with a single camera, a GPS receiver to geotag images, a monitor, and a remote control for shooting images while airborne, will also work well. The camera can be attached to the bottom of an aircraft with minimal modifications. Fees for aerial surveys should be offset by the reduced costs for the pesticide, and fewer chemicals will get into the soils and waterways, Yang says.—By **Dennis O'Brien,** ARS.

This research is part of ARS National Program #305, Crop Production.

Sniffing Out Overwintering Stink Bugs

DOO-HYUNG LEE (D3397-1)

USDA-APHIS detector dog named "Tig." In 2013, ARS scientists used detector dogs, like Tig, to find stink bugs with their sense of smell. The dogs were helpful in finding locations where stink bugs overwinter.

Since their first official detection in the United States in 2001, brown marmorated stink bugs have been eating our crops and invading our homes and businesses. Most stink bugs, however, seek shelter outdoors in order to survive the cold winter months.

Agricultural Research Service entomologist Tracy Leskey and her team at the Appalachian Fruit Research Station in Kearneysville, West Virginia, surveyed forests in Maryland and West Virginia to find out where stink bugs are hiding. They found that stink bugs like to overwinter in large, dry, dead trees that have a circumference of more than 23 inches.

"Oak and locust trees seem to be favorite stink bug overwintering sites," Leskey says. "The porous dead tissue and peeling bark make a great place for the bugs to crawl into and hide. The survey found stink bugs in 33 percent of the trees that fit those parameters."

The 2013 survey team included two detector dogs. The dogs were first trained to recognize the odor of adult stink bugs. Then, in indoor trials, they were guided by their handlers to find bugs hidden in cardboard boxes. Next, the dogs were trained in the field, where bugs were hidden beneath pieces of bark attached to living trees. In both indoor and outdoor trials, the dogs accurately detected target insects with greater than 84 percent accuracy. Next, the dogs were taken to woodland areas along the Appalachian Trail in Maryland. In these real-world conditions, the detector dogs were also able to find wild overwintering stink bugs.

As part of a project known as the "Great Stink Bug Count," citizens from the Mid-Atlantic, Midwest, and Pacific Northwest regions of the United States recorded daily counts of stink bugs, along with their locations on residences and the time of each tally.

In the first year's results from the Great Stink Bug Count, five types of locales were noted: mixed agriculture and woodland, agriculture, woodland, suburban, and urban. "Landscape type seemed to have the greatest influence on overall stink bug numbers arriving at specific homes," says Leskey. "We found that homes located in mixed agriculture and woodland sites had the greatest number of stink bugs. On average, these homeowners counted over 3,000 stink bugs. This was followed closely by agriculture and woodland locations." Suburban and urban dwellers counted fewer stink bugs.

In addition to landscape, home color plays a part in where stink bugs roam. "The greatest numbers of stink bugs were reported on homes with darker colors, particularly brown and green," says Leskey.

DOO-HYUNG LEE (D3400-1)

USDA-APHIS training specialist Jennifer Anderson and detector dog "Opal" successfully found overwintering stink bugs in a dead, standing tree in a wooded area.

DOO-HYUNG LEE (D3396-1)

ARS scientists found these brown marmorated stink bug adults beneath the bark of a dead standing tree. Trees like this one provide cool, tight, dry, and protected locations for the bugs to spend the winter.

DOO-HYUNG LEE (D3398-1)

A detector-dog team searches for brown marmorated stink bugs in a wooded landscape. USDA-APHIS training specialists Jennifer Anderson (left) with "Opal" and Jodi Daugherty with "Tig" search for their targets.

"Fewer bugs were reported on white and yellow homes. However, this was not always the case, and other factors likely had an influence on total stink bug populations arriving at particular homes."

Leskey notes that a home's exterior material matters, too. "Homes with wooden exteriors had the greatest number of stink bugs. Those with cement and stone also had high counts," says Leskey. "On average, lower counts were observed on homes with other materials, but again, this was not always the case. The variation we observed was likely influenced by other factors."

The Great Stink Bug Count was conducted again in 2014 to learn more about this variation. Many homeowners participated for a second year.

"Knowing where brown marmorated stink bugs overwinter is essential to future sustainable mitigation strategies, including integrated pest management programs," says Leskey. "Field surveys of highly dispersed and concealed overwintering stink bugs can be facilitated by the use of detector dogs. Such use should improve the accuracy and efficacy of sampling efforts."—By **Sharon Durham,** ARS.

This research is part of two ARS National Programs, Plant Diseases (#303) and Crop Production (#305).

Wheat Varieties Make Way to Breads and Malt Beverages

DAVE MARSHALL (D3389-1)

A field of Appalachian White hard white winter wheat growing in 2010 under certified organic conditions at Carter Farms in Eagle Springs, North Carolina. The variety was released in 2009 to farmers as a high-quality bread wheat suited to production in North Carolina, South Carolina, and Virginia.

Getting a product from research lab to the marketplace can be a long-term process. But two varieties of wheat, Appalachian White and NuEast, released for production in 2009 by a group led by an Agricultural Research Service scientist, have now become valued ingredients in products made by two North Carolina businesses.

David Marshall, research leader of the ARS Plant Science Research Unit in Raleigh, North Carolina, worked with collaborators at North Carolina State University to develop the two wheat varieties. NuEast is a hard red winter wheat, and Appalachian White is a hard white winter wheat.

Mills and bakeries in North Carolina have used the wheat varieties in some of their products. The ARS unit has a long-running project with Carolina Ground, an artisan mill and bakery in Asheville, North Carolina. "The owner, miller, and baker, Jennifer Lapidus, has used Appalachian White and NuEast in her artisan flours and baking recipes," says Marshall.

Appalachian White is also in use by another local establishment, Riverbend Malt House—the first malt house in the eastern United States. The owners, Brent Manning and Brian Simpson, produce barley, wheat, and rye malt, and their wheat malt is mainly made from Appalachian White wheat. Marshall is currently working with Riverbend Malt House on breeding a winter 2-row barley specifically for western North Carolina production.

The eastern United States is not hospitable to growing hard wheats, the type of wheat best suited for making breads and crackers, because the area's humidity increases the incidence of disease in the fields. This in turn affects yield and quality of the grain.

"NuEast had significantly higher grain yield than the check varieties over 4 years of field tests," says Marshall. "It has good resistance to leaf rust and is moderately resistant to stem rust, including Ug99 races."

Very few hard white wheats are grown in the United States. The main challenge with growing them in the humid eastern states is preharvest sprouting, according to Marshall. "In field tests, Appalachian White had significantly higher yield than the only other variety that could be considered acceptable when grown in the eastern states," says Marshall. Appalachian White also showed a higher level of resistance to powdery mildew, stripe rust, leaf rust, and Hessian fly, and good tolerance to preharvest sprouting.

"Being able to provide wheat varieties that fill the needs of local businesses is quite satisfying and makes the long journey from lab to market worthwhile," says Marshall.—By **Sharon Durham,** ARS.

This research is part of ARS National Program #301, Plant Genetic Resources, Genomics, and Genetic Improvement.

Novel Vaccines Effective Against Poultry Diseases

PEGGY GREB (D2048-1)

Microbiologist Qingzhong Yu examines recombinant Newcastle disease virus vaccine candidates in infected cells.

Vaccination is one method used to help prevent the spread of infectious poultry diseases, but current vaccines could be safer and more effective.

At the Agricultural Research Service's Southeast Poultry Research Laboratory (SEPRL) in Athens, Georgia, scientists are developing vaccines to help reduce virulent virus shedding—excretion of virus by a host—and disease transmission from infected birds to healthy ones.

Microbiologist Qingzhong Yu and his colleagues have created a novel vaccine that protects chickens against infectious laryngotracheitis virus (ILTV) and Newcastle disease virus (NDV), two of the most economically important infectious diseases of poultry. Both viruses cause sickness and death in domestic and commercial poultry as well as in some wild birds throughout the world.

"While current ILTV live-attenuated vaccines are effective, some of the viruses used to make them can regain virulence—causing chickens to become chronically ill," says Yu. "Other types of vaccines can protect birds from the disease's clinical signs, but barely reduce the virus shedding in their respiratory secretions after infection. Those vaccines are not that effective, because they do not reduce the risk of virulent ILTV transmission to uninfected birds."

For more than 50 years, the NDV LaSota strain has been used as an NDV vaccine worldwide. "It is very stable and very effective, and there have been no reports of virulence increase," Yu says.

In previous research, SEPRL scientists successfully used LaSota strain-based viruses to develop vaccines that protect birds against two other poultry viruses—metapneumovirus and infectious bronchitis virus. Now, in a recent study, Yu used reverse genetics technology, which allowed him to generate new vaccines by inserting a gene from the ILTV virus into the NDV LaSota strain.

The new vaccines were stable and safe when tested in chickens of all ages. Experiments involved more than 100 1-day-old Leghorn chickens and 120 3-day-old commercial broilers. All vaccinated birds were protected against both ILTV and NDV, showing few or no clinical signs and no decrease in body-weight gain.

These vaccines worked as well as current live-attenuated vaccines, Yu says. They can be safely and effectively administered by aerosol or drinking water to large chicken populations at a low cost.

"There is a huge market for these types of vaccines because they can protect poultry from ILTV as well as NDV," Yu says. "Developing a commercial vaccine that provides better protection against disease would have a positive economic impact on the U.S. poultry industry and also make its products—meat and eggs—less expensive for consumers."

ARS has filed for a patent on the vaccine invention, which has generated interest from private companies that are considering using this research to develop commercial vaccines.—By **Sandra Avant,** ARS.

This research is part of ARS National Program #103, Animal Health.

Shifting Out of High-Calorie Habits

PEGGY GREB (K10410-1)

Meals designed to reduce hunger include foods that are high in fiber, such as beans, lentils, peas, artichokes, bulgar wheat, pumpkin, and barley. The dish shown here is a barley soup.

A new study suggests that weight-loss interventions that center on hunger-reducing food choices and behavioral support can produce favorable shifts in "self-reward" areas of the brain. The study addresses concerns by weight-loss experts that when instant gratification, or addictive-type food involvement, becomes entrenched in the brain, it may be nearly impossible to reverse.

The study volunteers were 13 overweight or obese men and women assigned to one of two study groups. One group was placed on an at-home weight-loss intervention of lower calorie foods for 6 months with a goal of losing about 1 to 2 pounds per week. The other was a no-intervention control group eating normally at home.

To satisfy brain areas linked with cravings—the intervention group's diet provided about 45 to 50 percent of daily calories from "slow-digesting" carbohydrates and high-fiber foods. High-protein foods and healthy fats each provided about 25 percent of the other daily calories. The group received 1-hour support sessions most weeks and meal plans that centered on hunger reduction, portion-control, and high satisfaction. They were told to evenly space meals and snacks, and to freely use foods from a list of those with very few calories that could be eaten any time. These tips were designed to keep blood sugar levels even (versus spiking) and control hunger.

The study was conducted by senior coauthor Susan B. Roberts—an expert in developing programs for weight management—and colleagues. Roberts is with the Jean Mayer USDA Human Nutrition Research Center on Aging (HNRCA) at Tufts University in Boston. The center is funded by USDA's Agricultural Research Service. She is also professor of both nutrition and psychiatry at Tufts University.

Roberts has centered her work on "innate nutritional neurobiology," which is about helping people learn what "pushes their buttons" when it comes to staying in control of what they eat. "The abundance of affordable commercial foods that contain added sugars and low-satiety, refined grains and starches are food cues that stimulate the American palate," says Roberts. "Our studies have shown that just viewing pictures from mouth-watering food advertisements can activate brain-reward pathways and trigger the urge to eat." By understanding how brain circuitry stimulates eating in response to visual and actual food cues, Roberts has linked reducing cravings and increasing satisfaction with successful weight-control programs.

For the study, the team used magnetic resonance imaging (MRI) to assess neuronal activity in the brain's reward-response areas. The findings indicate that it is possible to change the cycle of constantly craving unhealthy foods by retraining the brain to stop activating its reward centers on exposure to a

steady stream of high-calorie food cues. (See sidebar below.) "A particular challenge is ongoing exposure to commercial foods that are formulated to overactivate the brain and trigger constant cravings," Roberts says.

All volunteers had two MRI brain scans—one at the beginning and one at the end of the 6-month study. During scanning, the volunteers were shown 20 images of high-calorie foods and 20 images of low-calorie foods. They rated the desirability of each image on a scale of 1 (none) to 4 (extremely) while blood flow to key brain areas was measured. Higher blood flow indicated greater neuronal activity.

Roberts was not surprised that the intervention group achieved significant weight loss—about 14 pounds. "Our key finding is that intervention-group participants had greater neuronal activity on their brain scans when viewing low-calorie food images at the end of the 6-month period versus when they viewed the same images before the intervention—a significant favorable shift," she says. "More studies to assess whether these positive changes in neuroplasticity can help people sustain weight loss over time are needed."—By **Rosalie Marion Bliss,** ARS.

Strategies To Control Cravings Are Key

Susan B. Roberts has been studying complex brain responses to the dramatically changed U.S. food supply that is described as the "obesogenic environment" in the "Dietary Guidelines for Americans" (DGAs) 2010. Roberts is the director of the Energy Metabolism Laboratory at HNRCA in Boston, which is funded in part by USDA's Agricultural Research Service.

The DGAs report that during the past four decades, the amount of food on hand to purchase from the U.S. market—in terms of average daily caloric availability—has increased by 600 calories per person.

Roberts emphasizes a moderately low carbohydrate intake rather than a very low carb intake, in keeping with the Recommended Dietary Allowance (RDA) for carbohydrates of 130 grams, or 520 calories, per day. "Carbohydrate intake at the lower end of the recommended range, rather than below it, is optimal for weight control," says Roberts. "It is a good level where people can enjoy some carbs, but not so many that they trigger food cravings and eating-control issues."

Another key to managing body weight is getting ample food fiber, which is a subset of the carbohydrate group, says Roberts. The daily adequate intake for fiber is 25 grams for women and 38 grams for men. Unfortunately, dietary fiber intake among U.S. consumers averages only 16 grams per day, according to ARS data from the Food Surveys Research Group in Beltsville, Maryland.

"For losing weight, I recommend at least 40 grams of fiber per day," says Roberts. "Fiber is one of our weight-control cornerstones because it helps achieve the feeling of fullness after eating."

Good sources of fiber include legumes (beans and peas), vegetables, fruits, nuts and seeds, and whole grains. The table below provides a short list of foods that are high in both fiber and slow-digesting carbs.—By **Rosalie Marion Bliss,** ARS.

FOOD	MEASURE	FIBER (as grams per measure)
Beans (navy, pinto, black, kidney, white, great northern, lima), cooked	1 cup	12.4 to 19.2
Split peas, lentils, chickpeas, cowpeas, cooked	1 cup	11.2 to 16.2
Artichoke, cooked	1 cup (hearts)	14.4
Green peas, cooked	1 cup	8.8
Black bean soup, canned	1 cup	8.4
Bulgur wheat, cooked (added to salads, soups, and other foods)	1 cup	8.2
Pumpkin, canned (a fat replacer when baking)	1 cup	7.2
Barley, pearled, cooked	1 cup	6
Flaxseed, ground (added to a variety of foods)	3 tbs, 21 grams, or 1 ounce net wt	5.7
Quinoa, cooked	1 cup	5.2
Broccoli, cooked	1 cup (chopped)	5.1
Pear	1 cup (cubes)	5.0

Yeast and Sugar Lure Pest to Beneficial Virus

PEGGY GREB (K11933-1)

A mature codling moth larva on a sliced apple.

TOM UNRUH (D3392-1)

Entomologist Alan Knight (left) and technician Ben Zeigler look at a yeast colony isolated from codling moth larvae allowed to walk across the nutrient media.

Common baking ingredients may offer a way to bolster the effectiveness of *Cydia pomonella* granulovirus (CpGV), a natural insect pathogen that's been commercially formulated to kill codling moth larvae, a pest of apple, pear, walnut, and other orchard crops.

Studies by Agricultural Research Service scientists and their Swedish colleagues show that adding two feeding stimulants—brewer's yeast and brown sugar—to the spray formulations can increase the pests' contact with, and ingestion of, the lethal insect virus, sparing more fruit from harm.

The scientists' investigations are part of a broader research effort to incorporate novel ingredients, or "adjuvants," that will improve CpGV's performance as a biobased alternative to broad-spectrum insecticides, which can be costly to apply and harmful to beneficial insects, as well.

Currently, CpGV is used on more than 370,000 acres of apples worldwide. But its effectiveness as a bioinsecticide can be diminished by exposure to ultraviolet light and by the larvae's tendency to burrow into fruit to feed shortly after hatching, says entomologist Alan Knight, at ARS's Fruit and Vegetable Insect Research Unit in Wapato, Washington.

In 2 years of field trials, the addition of sugar and brewer's yeast to sprays of CpGV killed more larvae (83 percent) than virus-only formulations (55 percent) and water-only controls (17 percent). The treatments also reduced feeding injury to the apples in 1 of the 2 test years, notes Knight.

Sugar/virus combinations were less effective than yeast/virus combinations, which, in turn, were less effective than virus/yeast/sugar formulations.

"We believe the sugar helps the yeast to grow, creating attractive volatiles that stimulate feeding, and that increases larval death through greater contact with the virus," Knight says.

Knight and Peter Witzgall, a professor of chemical ecology at the Swedish University of Agricultural Sciences in Alnarp, Sweden, came up with the yeast/sugar approach based on earlier findings that wild yeasts are important to larval health and survival. They found that some of the natural yeasts present on apple surfaces also grow in larval tunnels. There, the yeasts provide a nutritional boost to the insect's diet and prevent molds from growing.

The researchers are evaluating other natural adjuvants to make the virus more effective. These include feeding stimulants, such as pear ester; unpasteurized corn steep liquor; and some wild yeast species, including *Metschnikowia pulcherrima* and *Cryptococcus tephrensis.*

The virus is a potent biopesticide, exacting an ugly toll on codling moth larvae that ingest it, but it is harmless to nonhost insects, fish, wildlife, livestock, pets, and humans.

Knight welcomes collaborators interested in commercially developing the sugar/yeast blend as an adjuvant for CpGV or for use in other pest control applications.—By **Jan Suszkiw,** ARS.

This research is part of ARS National Program #304, Crop Protection and Quarantine.