



Well-Done Research

New recipes for making seriously browned meats less of a cancer risk

By JANET RALOFF

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Since a 1993 food-poisoning outbreak in the western United States killed four people who had eaten restaurant hamburgers tainted with bacteria, federal regulators have been on a crusade to make sure everyone cooks meat thoroughly.

The effort seems to have had an impact. Over the past few years, the number of people who choose to eat meat that is not thoroughly browned, inside and out, has been falling—at least when it comes to burgers and other ground meats, which are especially vulnerable to contamination.

This focus on food-poisoning risks, however, requires cooks to walk a fine line. They must make sure that meat is cooked well enough to destroy bacterial hazards but not so much that it forms compounds that can increase cancer risk.

While many cooks judge heating time by a meat's color, it proves an unreliable guide for doneness. Katherine Ralston of the Department of Agriculture cites recent research showing that meat frozen prior to cooking appears brown before it's hot enough to kill bacteria. Moreover, an acidic meat product like sausage can remain pink at germ-killing temperatures.

The chemistry of the carcinogens produced by grilling, which are known as heterocyclic amines (HCAs), is even trickier. A brief searing over a hot flame, for instance, can encase a burger or steak with a black, crispy crust without intro-

ducing any HCAs. Meanwhile, an uncharred steak that had been cooked longer at a lower temperature might be heavily laced with the carcinogens. Fat

content can also affect HCA formation, with leaner meats tending to be more vulnerable.

Even if cooks know how to grill meats

Meat and cherries—a healthy marriage

Having grown up in a small orchard, Cindy Pleva has always loved tart cherries. When she was 18 years old, the Michigan native became national cherry queen. Meeting with many growers, she learned that demand for the fruits of their labors was falling.

Sitting at the dinner table one night, she asked her dad if there wasn't something he could do to help her constituency. A butcher for 32 years, he began mulling over the request.



Ray Pleva displays a sampling of his cherry-laced meats.

A few months later, Ray Pleva offered up one idea at a local cherry festival in Traverse City. His cherry-pecan pork sausages sold like hotcakes and went on, later that spring, to grab top honors at a national new-foods exhibition in Chicago.

That was 11 years ago, and Ray Pleva has been mixing cherries into meat ever since. He's added the fruit to ground beef, buffalo, and turkey. He's developed cherry-laced chili, smoked sausage, bratwurst, meatballs, pork-sausage patties, and pizza toppings. His products are on school menus in 17 states, he says proudly, and are being distributed to retail stores in the Midwest, California, and Washington State.

Pleva promotes these products as being especially juicy, rich in fiber, and lower in fat—and sometimes sodium—than their fruitfree counterparts. Nationwide, he notes, sales of his patented cherried meats “will hit close to 5 million pounds this year.”

And that projection doesn't take into account any boost in consumer enthusiasm in response to cherries' anticancer potential. —J.R.

safely, a brief interruption can sabotage their effort. A phone call may beckon just when the burgers need flipping. The crucial last steps of a side dish may coincide with the meat's final stages of cooking. In the minutes it takes to deal with these distractions, a burger can go from well-cooked to overdone, rife with HCAs.

Unfortunately, there's no easy way to gauge whether those carcinogens have formed without sending the food to a lab specializing in HCA assays.

Short of turning vegetarian, what precautions can a diner take?

Researchers are investigating diverse approaches to quashing HCAs. Some laboratories are trying out a variety of preparation styles for meat, such as adorning the main course with sauces or marinades and using the microwave to precook meat for grilling. Other scientists are considering potential benefits for grilled-meat eaters of ale or beer chasers. The results of these experiments should prove welcome news to people who savor or, for whatever reason, favor well-done meats.

One novel solution for inhibiting HCAs: Add fruit to meat. Over the past few years, food scientist J. Ian Gray and his research team at Michigan State University in East Lansing have isolated a number of antioxidants from tart cherries (SN: 4/17/99, p. 247). These cherry pigments constitute "the most effective antioxidant [for meats] that I have ever seen," Gray says.

Because antioxidants can suppress HCA formation, Gray's team investigated the tart cherries' ability to keep HCAs out of burgers. Substituting ground cherries for 11.5 percent of the meat in hamburger reduced the formation of PhIP, the principal heterocyclic amine that forms when this meat cooks. The cherry burger had about 10 percent of the amount of PhIP in a pure grilled hamburger.

The treated meat has a subtle tartness and "a really mild cherry flavor that doesn't detract from the keynotes of the hamburger," Gray says. However, what people are most likely to notice, he says, is that "the meat is more succulent than you would expect from a hamburger."

Diners may also notice an improved flavor in leftovers of meat mixed with cherries. Cooking ordinarily kick-starts oxidation of a meat's fat and cholesterol, which within minutes initiates a process that leads to rancidity. These chemical changes not only diminish taste but may pose a health risk (SN: 5/4/85, p. 278). Though refrigeration or freezing can slow oxidative rancidity, neither stops it.

Cherries' antioxidants are so effective, however, that after 4 days of refrigeration, the meat's fatty constituents suffered only 50 to 65 percent as much oxidation as fruitfree burgers did, Gray reports. His team described its findings in the De-

ember 1998 JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY.

The researchers began the work in response to prodding by Michigan butcher Ray Pleva, who had spent 11 years developing a line of cherry-laced meats. Although Pleva initially incorporated the fruit into his products to boost the market for a local commodity (see sidebar, p. 264), cherry growers had related anecdotes conferring medicinal powers on the fruit.

Good as cherries are, Gray says, there is nothing magical about their chemistry. Because many tree fruits produce similar pigmented antioxidants, he suspects that a home cook could grind up a couple of tart plums, maybe even a bunch of grapes, and mix them into ground meat to achieve similar results.

Other studies by Gray's group have turned up another nutritious HCA inhibitor that won't affect taste—vitamin E.

In preliminary tests, the team recently demonstrated that adding vitamin E to

meats before cooking reduces HCA formation almost as much as cherries do. Treating a pound of ground beef, he notes, could be as simple as mixing in the contents of a 40 milligram vitamin E capsule.

Marinades can also shut down HCA production in meat, according to James S. Felton and Mark G. Knize of Lawrence Livermore (Calif.) National Laboratory (LLNL). For instance, they bathe chicken overnight in a heavily sugared oil-and-vinegar sauce. When the poultry finally is popped over a sizzling fire, it develops less than one-tenth as much PhIP as unmarinated chicken does.

However, Felton notes, "as levels of PhIP go down, methyl IQx [MeIQx] goes up." The latter is another carcinogenic HCA.

"The reason we think this happens," he says, "is that the sugar in the marinade is a catalyst for the reaction that makes MeIQx." Because PhIP is initially present in far larger quantities than MeIQx, even

How weighty is this cancer risk?

Diners who see red when their meat and poultry isn't thoroughly browned and seasoned with a hint of char might scoff at the notion that their taste preference jeopardizes their health. A growing body of data suggests, however, that well-done meat, rife with heterocyclic amines (HCAs), poses a substantial, preventable cancer threat.

In rat studies used to model human disease, these meaty compounds have proven "a surefire cancer risk," notes John H. Weisburger of the American Health Foundation in Valhalla, N.Y. "In my lab, we saw them [induce cancer] in both the colon and breast," he says. Researchers elsewhere have found evidence that these chemicals may also foster malignancies in the prostate, stomach, and pancreas.

Human data on HCA risks have just begun to emerge. For instance, women who routinely eat very well-done meat—with a crispy, blackened crust—face quintuple the breast-cancer risk of women who consume their meat rare or medium, according to a study last year by scientists at the National Cancer Institute (NCI) in Bethesda, Md., and two midwestern universities (SN: 11/28/98, p. 341).

Toxicologist Kenneth W. Turteltaub at Lawrence Livermore (Calif.) National Laboratory is part of an international team that has begun trials with patients to explore HCAs' relationship to colon cancer.

The researchers started with methyl IQx (MeIQx). After tagging this HCA with radioactive carbon, they packaged a small quantity into capsules—each containing an amount equal to that found in five well-done hamburgers. A physician then administered one cap-

sule to each of five British patients a few hours before surgery for the removal of colon tumors.

Samples of the cancer and surrounding tissue, excised during surgery, showed that the capsule's MeIQx had been activated into a form that binds to DNA, creating a potentially carcinogenic aberration known as an adduct.

Adducts were detected in both the cancerous and healthy colon tissue of the study participants. These adducts were chemically identical to those found in MeIQx-treated animals that went on to develop colon cancer. In fact, the only thing that distinguished the surgery patients' response to the HCA from that of the animals, Turteltaub told SCIENCE NEWS, is that for a given dose the patients made more of the adducts.

As such, "humans may possibly be at greater relative risk [from HCAs] than predicted from rodent-tumor studies," his team suggests in the Feb. 9 INTERNATIONAL JOURNAL OF CANCER.

In a follow-up test, another HCA, called PhIP, was given to seven U.S. patients 2 or 3 days before colon-cancer surgery. Each got a capsule containing an amount of PhIP equal to what has been measured in 6 to 10 ounces of well-done chicken or beef. As in the earlier trial, adducts of the ingested carcinogen showed up in the colon tissue.

"There is no doubt" that if HCA exposures are high enough, they can cause human cancer, concludes Elizabeth G. Snyderwine of NCI. What makes Turteltaub's data so important, she says, "is that they show there is a potential for human risk from exposures to very low levels"—ones easily encountered in the U.S. diet. —J.R.

if the marinade leads to a doubling in MelQx, "you still will have cut overall exposure to these HCAs," he says.

At the University of Hawaii's Cancer Research Center in Honolulu, Pratibha V. Nerurkar and her colleagues have just completed preliminary tests with three other marinades. Soaking steak overnight in a standard teriyaki sauce or a turmeric-garlic marinade cut the formation of both PhIP and MelQx during grilling. Depending on the cooking time, those reductions ranged from 40 to 65 percent.

The big surprise, Nerurkar says, was the effect of barbecue sauce. Upon grilling, steaks marinated in this tomato-based sauce developed two to three times more PhIP and three to four times more MelQx than unmarinated steaks did.

Neither Felton's nor Nerurkar's research team has deconstructed its marinades and tested each ingredient individually to identify which provide the bulk of the HCA inhibition. By contrast, John H. Weisburger, an organic chemist and director emeritus of the American Health Foundation in Valhalla, N.Y., knows exactly why his own meat sauce works. He concocted the recipe with ingredients known to short-circuit the chemistry behind the carcinogens' formation.

HCAs develop in heat-driven reactions between the amino acid creatinine and the sugar-based chemicals that give cooked meats their classic, and tasty, browned exterior. In 1988, Weisburger



Cooking hamburgers safely can be tricky. Though grilling will kill microbes on the surface of ground meat, it can leave live bacteria inside—unless the meat is well done. Yet the extra time or higher heat needed to ensure that the inside is fully cooked can produce toxic HCAs.

coauthored a paper that described how to shut down HCA production by tying up the creatinine through its binding to either of two other amino acids—L-tryptophan or L-proline.

Though he patented the amino acid combo as the basis of an HCA-inhibiting steak sauce 5 years ago, he only began seriously exploring the prospects of marketing "Weisburger's meat sauce" last month.

If marinades and fruit sauces are unappealing additions to the menu, there remains the simplest HCA treatment: precooking meat in the microwave.

Studies by Felton's group show that microwaving ground-meat patties for 2 minutes before grilling them can cut HCA in the finished burgers to 10 percent of the amount in grilled burgers that were not precooked. The microwave heating drives off a good deal of liquid, the data indicate, which removes many of the HCAs' raw ingredients.

Perhaps the most intriguing findings come from a series of new Japanese studies on the potency of various libations in defusing HCAs' harmful effects.

Several years ago, Sakae Arimoto-Kobayashi of Okayama University and her colleagues found that some of the pigments in *Monascus* fungi prevent genetic mutations. Because these fungi are used to make red sake, a fermented-rice drink, and because the fungi's polyphenolic pigments resemble some found in beer, Arimoto-Kobayashi's team decided to explore the effects of such beverages on HCAs.

Bacteria incubated with several HCAs tend to develop the type of mutations often used to gauge cancer risk. However, when dilute concentrations of beer, sake, or brandy were added to the microbial communities, HCAs were able to induce few such mutations, according to a report of the work in the January JOURNAL OF AGRICULTURAL AND FOOD CHEMISTRY.

Stout ale proved 10 times more potent than lager at inhibiting mutations due to the HCA known as Trp-P-2. Though sake, brandy, and white wine also inhibited DNA damage from this HCA, they were only about half as protective as lager—yet 10 times as effective as whisky. Nonalcoholic beer showed no effect.

When Arimoto-Kobayashi's team fed Trp-P-2 to mice, the chemical bound to the DNA in their livers, forming a structure known as an adduct. Adduct formation can be a first step on the path to many cancers.

However, when the researchers laced the animals' diet with some polyphenols that had been extracted from beer, adduct formation dropped dramatically.

The researchers conclude that alcoholic beverages such as beer may protect against some HCAs. However, in the tests using bacteria, even the best-acting beers offered no shield against the most prevalent HCAs produced in meat, such as PhIP and MelQx.

What all of these studies do indicate, Gray maintains, "is that there are a lot of things you can do in your home to counteract HCAs." Not only would most of these treatments cost little, but some actually make foods tastier and more nutritious. □

From the language maven whom William Safire calls "ek-STROOR-di-ner-ee" comes the definitive pronunciation guide to the words we love to wrangle over.

How do *you* pronounce *affluent*: AF-loo-int or uh-FLOO-int? Does it make a difference? Charles Harrington Elster believes that, yes, it does make a difference (and that, for the record, one should pronounce the word AF-loo-int).

Elster has chosen more than 1,000 of our most commonly mispronounced words, arranged them alphabetically, and written entertaining essays that unapologetically offer his informed opinion as to why a word should be pronounced in a particular way. When pronunciations vary or dictionaries disagree, Elster is an eager arbiter. Easy to use (there aren't any confusing diacritical marks) and with references ranging from Will Shakespeare to Will Smith, this book is an excellent argument settler—and debate starter.

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Houghton Mifflin, 1999, 426 pages
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