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REPORT

**Barbequer
Beware!**

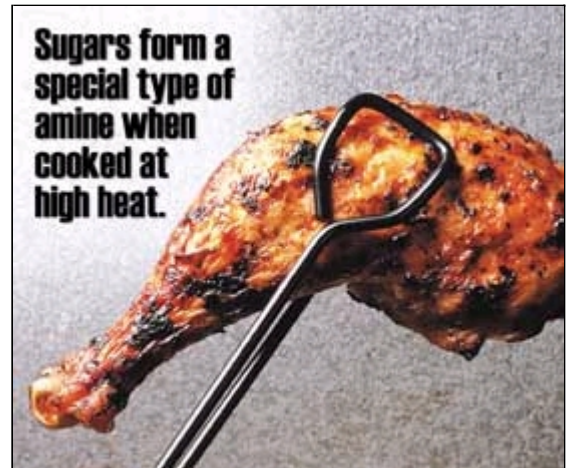
By Terri Mitchell

They're lurking in your favorite foods- barbequed chicken, smoky ribs, hamburgers. Even gravy is suspect. Heterocyclic amines (HCAs) are not funny. A good dose will give a rat cancer within weeks. Like your steak charred on the outside? How about a nice grilled salmon? Sound good? Read on.

Heterocyclic amines are brought to us by the same chemistry that gave us free radicals, and they're just about as welcome. These little molecules are created when heat breaks up amino acids and creatinine. High heat is the worst. HCAs are not free radicals themselves, but they provoke them. And they do things just as bad or worse. There's a bunch of different types, and researchers are beginning to think that these little devils are one reason meat-eaters are at risk for certain types of cancer. HCAs cause DNA mutations, especially in the colon. The liver and breasts are other well-studied targets for HCAs, but any organ is susceptible.

Lab 'Q

Some people will do anything to get out of work. Scientists at Lawrence Livermore held a barbeque (they say was in the name of science). Food Chemistry and Toxicology fell for it, and published the results of this gastronomical experiment in 1997. Grab a pen if you're up for a scientifically-proven marinade recipe. The group found that if you grill chicken without marinating it first, it not only tastes lousy, it has a lot more HCAs. In what must be a scientific first, however, it was reported that a mixture of olive oil, cider vinegar, garlic, mustard, lemon juice and salt protects grilled chicken against HCAs. The first time they tried this, one of the backyard scientists added brown sugar and messed the whole thing up. Sugar forms a special type of amine when it's cooked at high heat. (They hope to get funding to do steak in the future—without sugar).



Not to be outdone, researchers in Hawaii held a good, old-fashioned luau in the name of science, and threw in some special, ethnic marinade recipes. They didn't mess around; they used beefsteak. They found that an overnight soak in teriyaki sauce not only gave it that extra oomph, but produced the added feature of reducing HCA content by about 50%. Turmeric/garlic sauce created a similar effect (contact them directly for the recipe). Bottled honey barbeque sauce was a downer: it substantially increased amines. (Sugar again? The researchers have vowed to find out as soon as they get more grocery money).

Mindful of taxpayer dollars (or maybe they're all from the South), a group at the National Cancer Institute went the breakfast route. They cooked up pork chops, sausage, bacon and ham. Broiling meat doesn't seem to create much of an amine problem. Pan-frying, however, is amine city. Ham got off the hook, having few amines, and links didn't do too bad. But bacon was bad news.

For lunch, this group fried up some burgers and cooked a roast. Burger eaters beware: very well-done hamburger patties cooked in a pan have very high levels of HCAs (this has been confirmed many times). The amount of HCAs increases with increased cook time. In other words, medium-cooked meat has more HCAs than rare— well-done has the most.

HCAs and cancer

A group at the University of Minnesota reports that women who eat very well-done hamburgers have a 50% greater risk of breast cancer than women who eat them rare or medium. Women who consistently eat well-done steak, hamburgers and bacon have a 4.62 times increased risk of breast cancer. That's a significant risk, and the data is from 41,836 women who took part in the Iowa Women's Health Study—nothing to sneeze at.

Men—as head ‘Q chef, you’re not immune. Prostate cancer has been associated with eating meat; however, it’s not clear that heterocyclic amines are the culprit. It’s also not clear they’re not. Whatever the case, HCAs are likely suspects in other cancers that affect men, including colorectal, esophageal, lung, liver and small intestine.

A marinade mixture of olive oil, cider vinegar, garlic, mustard, lemon juice and salt protects against HCAs.



The typical diet of Uruguay contains a lot of salted and barbequed meat. When researchers went searching for answers behind the high rate of gastric cancers in that country, they looked for a potential connection between two types of HCAs and these foods. They found them. Each HCA they looked at (and there are many in one sample of food) was associated with a greater than three times increased risk of cancer. Similarly, researchers looking at lung cancer found that food containing high levels of HCAs (particularly from fried and/or well-done red meat) significantly increases the risk of getting lung cancer.

Things that stop HCAs

Back to those marinades. What, exactly, is it about them that keeps the lid on HCAs? Probably ingredients like garlic. Garlic and other plants contain substances that neutralize heterocyclic amines. Research has focused on a group of substances known as dietary phenolics. Phenolics is a broad category that includes flavonoids, flavonols and catechins. These guys possess antioxidant activity, but their protection against HCAs is due to a different mechanism.

Phenolics work by changing the way HCAs are metabolized. Just as estrogen can be metabolized different ways by the body, HCAs can too. Phenolics have the power to change the way HCAs are metabolized so that carcinogens are not created in the process. HCAs are normally broken down by p450 enzymes. Unfortunately, although the enzymes are natural to our bodies, HCAs are not. In trying to eradicate the strange invaders, p450 inadvertently turns them into carcinogenic substances. Phenolics interfere with the potentially deadly interaction between p450 enzymes and HCAs.

Phenolics, or “phenols,” come packaged in fruits, vegetables and tea. They appear to be among the strongest defense against heterocyclic amines. Green and black tea are the best HCA fighters discovered to date. They interfere with the ability of p450 enzymes to activate HCAs.

Researchers at the National Center for Toxicology Research have shown that green/black teas, tannic acid and quercetin interfere with the activation of HCAs by stopping a chemical reaction known as hydroxylation. In their experiment, bioactivation of a type of HCA known as PhIP was inhibited up to 90% by these nutrients.

Indole-3-carbinol (I3C), luteolin and caffeic acid also fight HCAs. A good place to find luteolin is artichoke extract. Rosemary contains at least two different types of luteolin. I3C is extracted from cruciferous vegetables such as cabbage, cauliflower and broccoli. Quercetin is a common polyphenol/phytoestrogen found in vegetables such as onions, grapes and green beans. In one experiment, quercetin, luteolin and caffeic acid “were found to clearly suppress the formation of both MeIQx and PhIP (HCAs). . .” Experiments on HCA inhibitors like luteolin have been done in vitro and in vivo, using both animal and human tissue.

Researchers at the Medical College of Ohio have found that I3C inhibits DNA breakage caused by HCAs in “virtually all organs” by 40% to 100% when tested in rats. Of particular significance is I3C’s protection of mammary glands. This suggests that I3C may be a good weapon for those who eat a lot of cooked meat, and are concerned about breast and prostate cancer. It doesn’t take a very large dose of I3C to stop HCAs. Other research by some of the same group shows that conjugated linoleic acid (CLA) also inhibits HCAs.

According to Japanese researchers, things like luteolin and quercetin are more active against a certain type of HCA than tea. Again, these substances work by inhibiting enzymatic reactions that make the HCA carcinogenic, not by direct antioxidant activity. (Quercetin, for example, directly controls cytochrome p450). This experiment points up the importance of getting a variety of HCA-fighters everyday. While one nutrient may work against one type of HCA, another type may be needed against other kinds of HCAs.

Chlorophylls have action against HCAs, and so does miso. However, the research on these is scant. For now, the best proven protection against heterocyclic amines are plant extracts such as I3C, luteolin (artichoke), green tea, black tea, rosemary and garlic. Cooked meat, especially well-done red meat and bacon, should be kept at a minimum. If you’re one of those people who eats a charbroiled or well-done pan-fried hamburger everyday for lunch, you might want to reconsider.



Rosemary contains at least two different types of luteolin.

References

- Ciolino HP, et al. 1999. Dietary flavonols quercetin and kaempferol are ligands of the aryl hydrocarbon receptor that affect CYP1A1 transcription differentially. *Biochem J* 340 (pt3):715-22.
- Dashwood RH, et al. 1999. Cancer chemopreventive mechanisms of tea against heterocyclic amine mutagens from cooked meat. *Proc Soc Biol Med* 220:239-43.
- De Stafani E, et al. 1998. Dietary nitrosamines, heterocyclic amines, and the risk of gastric cancer: a case-control study in Uruguay. *Nutr Cancer* 30:158-62.
- Hammons GJ, et al. 1997. Metabolism of carcinogenic heterocyclic and aromatic amines by recombinant human cytochrome P450 enzymes. *Carcinogenesis* 18:851-4.
- HCAvaniya N, et al. 1997. Inhibitory activity of green and black tea in a free radical-generating system using 2-amino-3-methylimidazo[4,5-f]quinolone as substrate. *Jpn J Cancer Res* 88:553-58.
- He YH, et al. 1999. Inhibition of DNA adduct formation of 2-amino-1-methyl-6-phenylimidazo [4,5-b]pyridine and the 2-amino-3-methylimidazo [4,5-f]quinoline by dietary indole-3-carbinol in female rats. *J Biochem Mol Toxicol* 13:239-47.
- Kanazawa K, et al. 1998. Antimutagenicity of flavones and flavonols to heterocyclic amines by specific and strong inhibition of the cytochrome P450 1A family. *Biosci Biotechnol Biochem* 62:970-77.
- Lewis AJ, et al. 1998. Bioactivation of the cooked food mutagen N-hydroxy-2-amino-1-methyl-6-phenylimidazo(4,5-b)pyridine by estrogen sulfotransferase in cultured human mammary epithelial cells. *Carcinogenesis* 19:2049-53.
- Nerurkar PV, et al. 1999. Effects of marinating with Asian marinades or western barbecue sauce on PhIP and MeIQx formation in barbecued beef. *Nutr Cancer* 34:147-52.
- Salmon CP, et al. 1997. Effects of marinating on heterocyclic amine carcinogen formation in grilled chicken. *Food Chem Toxicol* 35:433-41.
- Schut HA, et al. 1997. DNA adducts of heterocyclic amines: formation, removal and inhibition by dietary components. *Mutat Res* 376:185-94.
- Sinha R, et al. 1998. Heterocyclic amine content of pork products cooked by different methods and to varying degrees of doneness. *Food Chem Toxicol* 36:289-97.
- Sinha R, et al. 1998. Heterocyclic amine content in beef cooked by different methods to varying degrees of doneness and gravy made from meat droppings. *Food Chem Toxicol* 36:279-87.
- Sinha R, et al. 1998. Fried, well-done red meat and risk of lung cancer in women (United States). *Cancer Causes Control* 9:621-30.
- Zheng W, et al. 1998. Well-done meat intake and the risk of breast cancer [see comments]. *J Natl Cancer Inst* 90:(22)1724-9.

[Back to the Magazine Forum](#)

treatment. You should consult with a healthcare professional before starting any diet, exercise or supplementation program, before taking any medication, or if you have or suspect you might have a health problem. You should not stop taking any medication without first consulting your physician.