Cholesterol: Up in Smoke

Cooking meat dirties the air more than most people realize

By JANET RALOFF

Sizzle, sizzle. It's summer, company's coming and you don't want to heat up the kitchen. So, like millions of other Americans this season, you throw a few burgers on the backyard grill. Sizzle, spat. That smoky charbroiling imparts a picnic flavor to even the most mundane fare. And for years, nutritionists have extolled the health advantages of broiling instead of pan frying, since it allows much of the saturated fat to drip away before the meat ever reaches your lips.

But from an air-quality perspective, it would have been better to stick to pan frying — and better yet to switch to an entree that needn't sizzle and spatter, a team of researchers now concludes.

While it's no secret that charcoal fires foul the air, cooking meat makes its own contribution to pollution, assert Glen R. Cass and his colleagues at The California Institute of Technology in Pasadena. Ground beef, for instance, emits dozens of compounds as it cooks, including a bevy of hydrocarbons, furans, steroids and pesticide residues. Just how prolific a polluter that burger becomes depends on the meat you buy and how you cook it. "Fine aerosol emissions from charbroiling of regular hamburger meat are higher than from charbroiling extra-lean meat, which in turn are much higher than the emissions from frying the same amount of hamburger," the researchers write in the June ENVIRONMENTAL SCIENCE & TECHNOLOGY (ES&T).

Nor is meat a trivial source of pollution. The Caltech group's analysis indicates that meat smoke may constitute "the dominant source" of the fine organic particles -- 2 microns or smaller — polluting urban air. Their minuscule size makes these particulates the most easily inhaled of all organic aerosols.

Though homeowners aren't likely to rig up devices that trap these aerosols as they spew from sizzling meat, commercial kitchens could well make a difference by installing filters to capture the particulates in the smoke belched out by their exhaust fans. At present, however, the Environmental Protection Agency does not require restaurants to take such measures.

Cass focused on the smallest aerosols not because of their breathability but because they play a primary role in Los Angeles' visibility-robbing haze, which he describes as "a problem of worldwide note and local disgust."

These particulates "are about the size of [those in] cigarette smoke, will mix almost as readily as a gas and will have a residence time in the atmosphere of days," he explains. Overall, carbonaceous materials make up the biggest share — roughly 40 percent — of fine airborne particles polluting the Los Angeles area. Soot represents about one-third of that contribution, according to earlier findings by one of Cass' students. The remaining, "organic" fraction has largely gone unstudied, Cass contends, because its chemistry is so complicated and costly to analyze.

But last spring, Cass and his coworkers quantified 29 different sources of tiny organic particles in Los Angeles' air. In the April ES&T, they reported that meat smoke appears to account for more than one-fifth of these particles, substantially exceeding any other single source — including fireplaces, gasoline- and diesel-powered vehicles, dust raised during road paving, forest fires, organic chemical processing, metallurgical processing, jet aircraft and cigarettes.

Grilling's environmental effects have come under scrutiny before. In California, home of the nation's toughest air pollution laws, the South Coast Air Quality Management District — a regional pollution control agency — passed regulations last October prohibiting the use of standard, highly volatile charcoal lighter fluid to ignite backyard barbecues in the greater Los Angeles area. But those regulations, due to take effect next January, arose from concern over emissions from the fuel — not from the main course.

After spending nearly a decade investigating the sources and quantities of the carbonaceous aerosols in urban air, Cass says he wasn't especially surprised by meat smoke's relative ranking. A walk through any metropolitan area, he says, will confirm that few activities regularly discharge as much uncontrolled smoke as commercial charbroiling operations.

But meat smoke's ranking in the April paper emerged from measurements made in the lab, not on the street. To verify its contribution to urban pollution, the researchers needed to identify a prevalent compound that uniquely characterizes meat smoke, and then confirm the "marker" compound's presence — at predicted concentrations — in the atmosphere.

So they fried and charbroiled regular (21 percent fat) and extra-lean (10 percent fat) hamburgers over a natural-gas-fired stove typical of those in restaurants. They used natural gas because the April study had demonstrated that its release of fine carbonaceous aerosols is "very, very small — and not of consequence," allowing the researchers to isolate the contributions of the meat itself. And they focused on hamburger because a 1979 EPA study had shown that people in the United States consumed about 40 percent of their meat in restaurants, and that ground beef constituted about half of that meat.

Careful chemical analysis revealed more than 75 discrete compounds in the hamburger smoke. When the researchers compared meat smoke's organic-particulates profile against air samples collected in west Los Angeles during 1982, they discovered the marker they needed for tracing hamburger emissions: cholesterol.

Though dozens of chemical ingredients exist in both meat smoke and the fine organic aerosols in Los Angeles, cholesterol was "one of the more unusual," the researchers note. Unlike many of the others, cholesterol had few other major, identifiable sources.

The group also identified a supplemental set of six tracer compounds in meat smoke: myristic acid, palmitic acid, stearic acid and oleic acid (all fatty acids), together with nonanal (an aldehyde) and 2-decanone (a ketone). Though each of these air pollutants can arise from several different sources, meat smoke combines them in a distinctive ratio.

Quarter-pound hamburgers fried until medium to well done spewed into the air roughly 7 milligrams of cholesterol per kilogram of meat. Extra-lean burgers charbroiled on the gas grill to the same doneness emitted roughly four times more cholesterol, and broiling the fattier meat released 72.7 mg/kg of airborne cholesterol – 10 times more than the fried hamburgers.

To arrive at a ballpark estimate of how this might translate into urban air pollution, the investigators went back to the 1979 EPA report. At that time, an estimated 9 percent of restaurant meats were charbroiled. Cass' group assumed that this percentage would also apply to Los Angeles restaurants and home cooks in 1982, when a Caltech student had collected the air samples they were studying. To keep things simple, the researchers assumed that all meat cooked in the Los Angeles area was ground beef.

By marrying their meat-smoke emissions data with published estimates of meat consumption in the metropolitan area, the team projected that fried and broiled meat released 25.6 to 30.4 kilograms of tiny cholesterol aerosols into the atmosphere daily over a highly urban 6,400-square-kilometer region centered on Los Angeles. When they went on to assay the cholesterol in their October 1982 air samples, they found concentrations of 14.6 nanograms per meter cubed – or about double their ballpark prediction of what should be there.

That's actually a remarkably small difference, says Cass, especially when one considers that the October air sample was chosen for the comparison because it featured the biggest, clearest cholesterol "signature."

Cass, currently on sabbatical at the Massachusetts Institute of Technology, is studying the meat smoke's effects on bacteria as an initial rough gauge of its potential toxicity and mutagenicity in humans. While he has no findings yet, studies reported earlier this year by EPA epidemiologist Joel Schwartz indicate that fine particulates can play an important role in aggravating respiratory disease (SN: 4/6/91, p.212). Schwartz' analyses of data from five U.S. cities show that nonaccidental death rates in each of these cities tended to rise and fall in near lockstep with daily levels of fine particulates – but not with other pollutants.

Los Angeles' new lighter-fluid rule aims not at reducing particulates but at halving the emissions of hydrocarbon gases from backyard grilling, which contribute about 4 tons of hydrocarbons per day to the metropolitan area's seemingly intractable smog-ozone problem – the worst in the nation. However, the South Coast Air Quality Management District may extend its hydrocarbon-control program to restaurant charbroiling operations, and may tack on requirements for filtering out particulates 10 microns and smaller, says Claudia Keith, an agency spokeswoman.

The Caltech group's June report may also give environment-minded carnivores an impetus to explore alternative hot-weather cooking methods, such as microwaving. Some might even decide to forgo broiled and fried meats altogether.

How about tabouli, cold poached salmon and perhaps a carrot salad lightly dressed with an olive-oil vinaigrette? □

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the idea that the Earth is round. The problem with the large-scale structure found in the universe is that it is clearly 10 times *older* than the 10 or 20 billion years the Big Bang theory allows for the age of the whole universe.

The vast ribbons of galaxies recently observed are separated by nearly a billion light-years of space. So to form them, matter has to travel half that distance, if the universe was originally smooth. But galaxies are observed to travel at only about 1/600th the speed of light, so the huge structures must have taken at least 200 billion years to form. Having 200-billion-year-old structures in a 20-billion-year-old universe causes the same sort of problems as having millions-of-years-old mountains in a biblical 6,000-year-old Earth.

Eric J. Lerner
President, Lawrenceville Plasma Physics
Lawrenceville, N.J.

Our continuing search for a beginning of the universe and for spatial boundaries, however remote, strongly suggests to me that man is inherently unable to understand and accept infinity. If we could do so, then I believe we could accept the idea that there was no beginning, no Big Bang, and that all of it has always been there. And that there are no limits.

James Hartley
Columbus, Ind.

When we discard the unnecessary assumption that the beginning had to occur at a single point in a finite space, we are left with the rather obvious alternative that the beginning actually occurred everywhere. If we conceive of a "Super Bang" cosmology that occurs all at once, everywhere, we find that the change in perspective can explain all our observations without the problems of Big Bang theory.

Tom Mandel
LaGrange, Ill.

What if the Big Bang is really the Big Bust? Perhaps we need to view the evidence from the outside in. Maybe what we're seeing isn't a shock wave rolling outward but a transition front between a region of higher order and one that is more entropic. It might be that the redshifting of galaxies should be viewed as the deceleration of congealed energy into our three-dimensional universe rather than as the rapidly moving outer edge of an explosion.

Paul A. Daugherty
Brandon, Fla.

Could not the same linear distance-redshift relationship known as Hubble's law exist in the case of a contracting universe if the rates of contraction were exactly reversed from those assumed under the Big Bang theory?

M.E. Renshaw
Portage, Mich.

A Big Bang followed by a series of "aftershocks" might account for the lumpy structure of the universe. It's hard enough to detect the effects of the Big Bang with any kind of certainty; "Little Bangs" would surely be lost in the general background information.

William E. White
Miami, Fla.

It sounds to me like the conditions at the early stages of the Big Bang universe (a lot of stuff in a small amount of space) are identical to the requirements for a black hole.

Supposedly, there is no explosion powerful enough to blast its way out of a black hole. Therefore, I suppose, we are living in a black hole.

Tom Paskal
Montreal, Quebec

The recent calls for a replacement to the Big Bang hypothesis at international conferences on plasma science and on magnetic fields in galaxies suggest that, for the first time in 30 years, the number of researchers working on alternative scenarios actually exceeds those actively working on the Big Bang. The latter, however, seem ignorant of this work.

Anthony L. Peratt
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I was struck by a singular omission in your excellent article on the Big Bang controversy: There was no mention of the late George Gamow.

As a minor player in the cosmic-ray research of the 1950s, I can remember when Gamow, with his "Big Bang" theory, was the radical physicist scorned by most astrophysicists. Today's "elderly radicals" were then the Establishment, riding high with their "steady-state universe," as evidenced by the many papers by "Burbidge, Burbidge, Fowler & Hoyle." The Big Bang was pooh-poohed, and Gamow was characterized as "a writer of comic books."

Robert E. McDaniel
Las Cruces, N.M.