

Grilling and Air Pollution

Introduction

Grilling is one of the simplest and most popular forms of cooking. However, due to the harmful carcinogens and chemicals that are produced in the process of cooking, the method is a contributor to indoor and outdoor pollution.

Particles

Cooking fumes are known to contain mutagenic and carcinogenic substances, such as fine particulate matter (PM_{2.5}), black carbon, heterocyclic amines (HCAs), and polycyclic aromatic hydrocarbons (PAHs).

Formation

HCAs (carcinogen) – form when creatine and amino acid react under high temperature cooking

PAHs - PAHs were formed as lipid material dripped from the meat onto the cooking appliance.

Emission rates are varied by meat, temperature, and type of appliance.

Meat

- PAH emissions from charcoal-broiled steaks, chicken, hamburgers, and hot dogs and found that hamburgers emit the largest amount of PAHs
- PAH production is directly proportional to the fat content of the food item. High-fat (31%) hamburger cooked on an under fired charbroiler yielded the highest emissions.
- Food with lower fat content such as vegetables and fruits may have lower amounts of PAHs but still contain anthracene (limited info.) and benzopyrene (highly carcinogenic).

Temperature

PAHs are formed between 1022 and 1742 °F, and maximum PAH production occurs at approximately 1436 °F. PAH emissions decrease at temperatures above 1472 °C.

Charcoal vs Charbroil vs Gas

Charcoal

- Aerosol emission: PM_{2.5} (7380 ± 353 mg/kg of dry charcoal fuel burned), CO₂, CO (219 ± 44.8 g /kg dry charcoal burned), NO_x (3.01 ± 0.698 g/kg dry charcoal burned), PAHs(88.9 µg/g PM_{2.5}), metals (Fe&Zn), and PM₁₀, VOCs (only detected in samples from the charcoal grilled chicken, and benzene has highest emission rate)
- Footprint of one session of charcoal grilling is 6.7 kg of CO₂ = driving an average car for around 22 miles
- Charcoal grilling gives rise to the highest amount of PAHs when compared to gas grilling or electric oven roasting.

Charbroil (inside use, lidless)

- Aerosol emission: fine particles (<2.5 µm) (4.4 to 15.0 g/kg of meat cooked), carbon (organic/elemental), inorganic ions (SO₄²⁻, NO₃⁻, NH₄⁺), elements (primarily metals),

and organic compounds like PAHs (45 mg/kg of meat cooked), cholesterol (7 and 8 mg/kg of meat cooked), and lactones

- One single charbroiled hamburger patty = 10 miles driving of a diesel engine truck

Gas

- The use of gas does not contain PAHs, and the prevailing temperature in the gas combustion chamber of approx. 392 °F is unfavorable for PAHs formation.
- Gas-powered grill releases 105 times less carbon monoxide than charcoal grill

Indoor vs Outdoor

- Charbroiling emissions yields an average of 3–5 times more PAHs, 20 times more cholesterol, and 10 times more lactones than outdoor grilling

Risk

- The estimated cancer risk for people who would inhale barbecue particles for 5 h a day, 40 days a year exceeds the acceptable level set by the U.S. Environmental Protection Agency.
- Genotoxicity studies also found that PM_{1.0-0.56}, containing the largest amount of carcinogenic PAHs such as BaP, induced the highest DNA adduct levels. Therefore, the relatively high levels of PM and BaP near the charcoal-grill stall stove should be of health concern.

Social Implications

- In Beijing, China, outdoor grilling has been banned. Anybody who violates this is forced to pay a 20,000 Yuan (\$3,200) fine.
- In USA, however, American still consumes three hamburgers a week; a total of 50 billion burgers a year. In fact, 75 percent of adults in the United States own an outdoor grill, and 87 percent of those grills are used on the Fourth of July. 882 million pounds of CO₂ is emitted on Fourth of July, which is equivalent to run a coal-fired power plant for a month.
- In 2015, EPA decided to use \$15,000 of taxpayer money to fund a project designed to decrease "particulate matter emissions" from backyard grilling(?)

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