Influence of different fuels and grillables on particle emissions during an outdoor barbeque

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Barbecueing is conducted in different styles as a recreational activity in many countries around the world even though early studies (Elmenhorst and Dontenwill 1967; Dyremark and Westholm 1994) had shown severe health risks due to particle formation from hazardous substances. Following studies mainly dealt with indoor cooking activities because of the more controllable experimental conditions. This study was conducted outside under realistic winter time conditions in order to test for influences of fuel and grillables on particle formation and their potential health risk.

The experiment was conducted in two separate runs. First, wood, charcoal (loose and briquettes), gas and pine cones have been used as fuel and a mixed beef-pork burger as grillable in order to test for the influence of different fuels. Second, gas was used as a low emission fuel and the grillables were vegetables (with and without oil), pork (lean and fatty), turkey, pork sausages and a mixed beef-pork burger in order to test the influence of different grillables. Temperature was tracked in order to take into account differences caused by different fuels.

Particles in the range of 10 – 750 nm were measured using a stationary Scanning Mobility Particle Sizer (SMPS) with an inlet installed one meter above the grill. Additionally, the grill master was equipped with a portable optical particle spectrometer (OPC; diameter range 0.3 µm to 10 µm, 6 channels) with an inlet of a 30 cm PTFE-tube placed at his breast. During the first run of the experiment particles were additionally collected on a quartz-filter placed next to the SMPS inlet. These filters and samples of the solid fuels and of the meat have been analyzed via temperature-programmed-pyrolysis mass-spectrometry (TPP-MS) to gain information about the composition of the pyrolysed material.

SMPS measurements show the highest particle emissions for pine cones in comparison to the other solid fuels (Fig. 1). Charcoal and briquettes have lower emissions than wood. As gas exhibits the lowest total aerosol emissions it was used as standard fuel for the comparison of various grillables. As indicated by mean PM1/PM10 ratios derived from OPC measurements, gas has the highest fraction of small particles which is supported by SMPS data.

The amount of fat in grillables does not only influence the total emitted aerosol concentration but also impacts the size distribution of the emitted particles. As a general result, our hypothesis that more fatty grillables tend to emit larger particles was confirmed. Nevertheless, most particles have diameters below 200 nm, which cannot be neglected for discussing health risks.

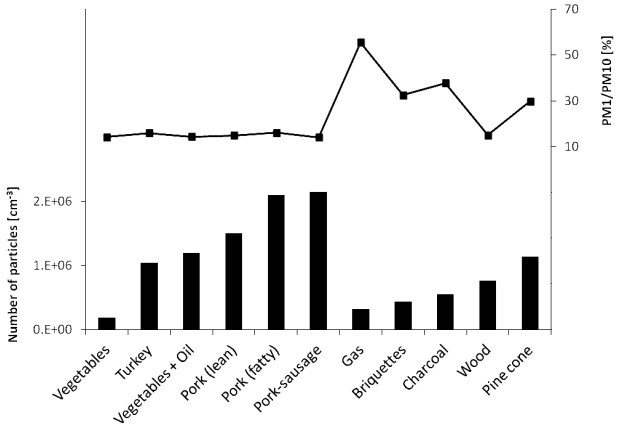

Figure 1. Numbers of emitted particles per cm³ during the main grill process (SMPS), and PM1/PM10 ratio (OPC)

TPP-MS results show that emitted organic aerosols are mainly oxidized, especially for larger molecules in both charcoal and briquettes. Within single measurements the most larger molecules were emitted at a pyrolysis – temperature of 550-600 °C for the solid fuels. The pyrolysed meat did not show this unique pattern. In consequence, aerosol samples are considered a mixture of meat- and fuel-derived particles.

Altogether the described experiments show that total number, size resolution and composition in chemistry differ significantly as a function of both grill fuel and grillables. Fat seems to be a major control for total particle number and dominant particle size.

Dyremark, A.; Westerholm, R; Övervik, E.; Gustavsson, J. (1994): *Polycyclic aromatic hydrocarbon (PAH) emissions from charcoal grilling*. Atmospheric Environment, 29, No.13, pp. 1553-1558.

Elmenhorst, H.; Dontenwill, W. (1967): *Nachweis cancerogener Kohlenwasserstoffe im Rauch beim Grillen über Holzkohlenfeuer.* Zeitschrift für Krebsforschung, 70, pp.157-160.