

# Emissions of PM<sub>2.5</sub>-bound organic compounds from different cooking styles



## Introduction

Atmospheric aerosols remain a growing field of scientific interest due to their established role in climate change and their effect on human health. In addition to traffic and biomass burning, cooking emissions have been found to represent a great contribution to the atmospheric particulate matter (PM) levels (Zhou *et al.*, 2014). The aim of this study was to characterise and estimate the emission rates of organic compounds emitted from different Portuguese cooking styles.

## Methods

PM<sub>2.5</sub> samples were collected on the roofs of a university canteen, a charcoal-grilled chicken restaurant and a wood-oven roasted piglet restaurant, all located in the region of Aveiro, Portugal.

### University canteen



### Charcoal-grilled chicken restaurant



### Wood-oven piglet restaurant



### PM<sub>2.5</sub> gravimetric quantification

Analysis of the organic compounds by gas chromatography-mass spectrometry. The emissions rates of organic compounds during operation hours were calculated using the methodology described by Alves *et al.* (2015) and Chen *et al.* (2007).

## Conclusions

The use of charcoal or wood for cooking activities caused much higher emissions than cleaner fuels.

The highest amount of PAHs was obtained for the roasted piglet restaurant during the oven heat-up phase. PAH concentrations were approximately 100 and 700 times higher than the ones recorded in the chicken restaurant and university canteen, respectively.

Due to the higher fat content, the amounts of palmitoleic acid emitted from the chicken and roasted piglet eateries were 60 and 30 times higher than values obtained in PM<sub>2.5</sub> samples from the university canteen, respectively.

## Results

Description of the samples and type of food				
University Canteen	Boiled chicken with vegetables	C1	Oven preheating with remains of pruning vines and pine slats (flaming)	
	Fried fish and seafood rice	C2		
	Veal stroganoff stew	C3		
	Boiled pork meat with vegetables	C4		
	Roasted ribs	C5		
	"Alentejo" pork meat with clams; stewed pork chops with sausages	C6		
	Grilled pork	C7		
	Beef with rice and pork with boiled potatoes	C8		
	Grilled and boiled fish	C9		
	Chicken stew and turkey stew with rice	C10		
Charcoal-grilled chicken Restaurant		K	Oven heat-up phase	
				Smouldering and glowing embers
Wood-Oven Roasted Piglet Restaurant			Tray with rice soaked in chicken's blood; glowing embers at the bottom; door open occasionally to spread ashes on the embers	
				Three piglets in the oven; glowing embers at the bottom; door open

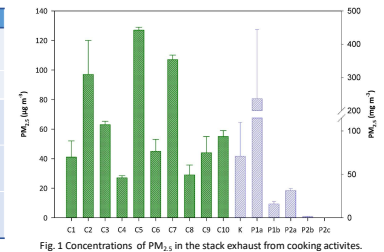


Fig. 1 Concentrations of PM<sub>2.5</sub> in the stack exhaust from cooking activities.

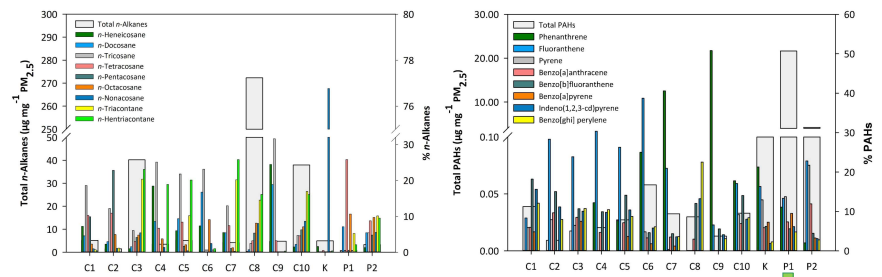


Fig. 2 n-Alkane mass fractions in PM<sub>2.5</sub> collected in the stack exhaust from cooking activities and relative average contribution of the major compounds to total n-alkanes.

Fig. 3 Total PAH mass fractions in PM<sub>2.5</sub> collected in the stack exhaust from cooking activities and relative average contribution of the major individual PAHs to total PAHs.

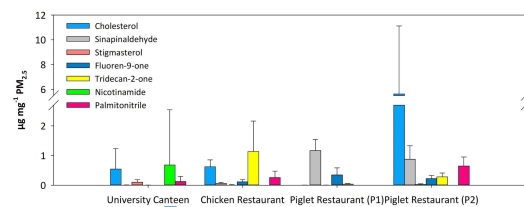


Fig. 4 Average mass concentrations of some representative compounds measured in the stack exhaust from cooking operations.

The largest contribution to the total annual emissions of PAHs is from the roasted piglet restaurant during the oven heat-up phase (131±128 kg year<sup>-1</sup>). Benzo[a]pyrene accounted for 9.9% of the total annual emissions.

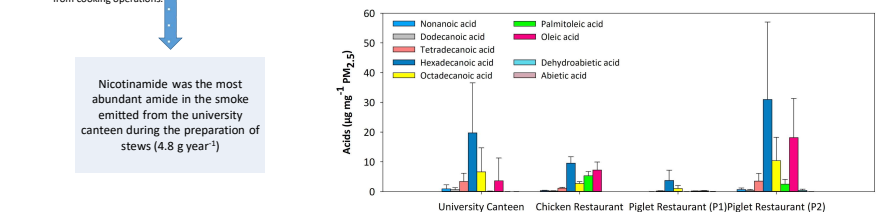


Fig. 5 Average mass concentrations of saturated and unsaturated fatty acids and diterpenoid compounds measured in the stack exhaust from cooking operations.

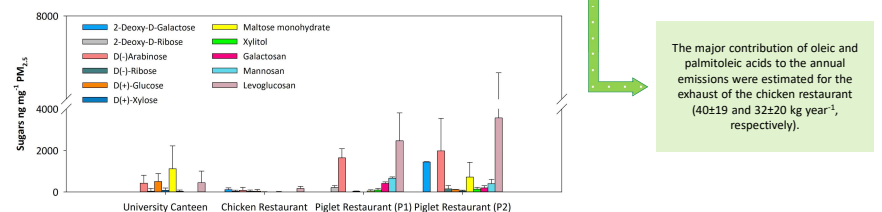


Fig. 5 Average mass concentrations of sugar compounds measured in the stack exhaust from cooking operations.

The major contribution of oleic and palmitoleic acids to the annual emissions were estimated for the exhaust of the chicken restaurant (40±19 and 32±20 kg year<sup>-1</sup>, respectively).

## References

- Alves, C.A. *et al.* (2015) Volatile organic compounds emitted by the stacks of restaurants. *Air Qual. Atmos. Health*, 8, 401-412.  
Chen, Y. *et al.* (2007) Gaseous and particulate polycyclic aromatic hydrocarbons (PAHs) emissions from commercial restaurants in Hong Kong. *J. Environ. Monit.*, 9, 1402-1409.  
Zhou, Z. *et al.* (2014) Chemical characterization and source apportionment of household fine particulate matter in rural, peri-urban, and urban West Africa. *Environ. Sci. Technol.*, 48, 2, 1343-1351.

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