Emissions of anhydrosugars from diverse residential biomass combustion equipment

C.A. Alves[1], E. Vicente[1], C. Gonçalves[1], C. Colombi[2], and V. Gianelle[2]

[1]Centre for Environmental and Marine Studies, Department of Environment, University of Aveiro, 3810-193 Aveiro, Portugal

[2] Regional Centre for Air Quality Monitoring, ARPA Lombardia, Via Juvara 22, 20122 Milan, Italy

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Presenting author email: celia.alves@ua.pt

Levoglucosan, mannosan and galactosan have been shown to be specific tracers for both residential wood combustion and wildfires (Engling *et al.* 2006; Schmidl *et a*l., 2008; Vicente *et al*., 2012). The levoglucosan to mannosan ratio (L/M) has been described to be wood type specific, with low ratios for softwoods and higher values for hardwoods (Engling *et al.* 2006; Schmidl *et al*., 2008). However, the use of levoglucosan as a quantitative tracer may be associated with large uncertainties since laboratory measurements have shown large variations in emissions, depending on the type of stove, biofuel quality, and operator behaviour (Hedberg *et al*., 2006).

In this study, wood species widely used as biofuels in residential combustion in Southern European countries were burned in a fireplace, a traditional cast iron woodstove and an eco-labelled stove. Additionally, seven fuels (four types of wood pellets and three agro-fuels) were tested in an automatic pellet stove. Levoglucosan and its stereoisomers were analysed in the particulate matter emission samples by gas chromatography coupled to mass spectrometry or by ion cromatography with amperometric detection.

Levoglucosan mass fractions (mg g^{-1}) in smoke particles from the fireplace, traditional woodstove and eco-labelled woodstove (Fig. 1) were, respectively, in the following ranges: 49.8 (olive) – 149 (eucalypt), 22.4 (olive) – 232 (briquettes) and 23.0 (Golden wattle) – 119 (eucalypt). The anhydrosugar encompassed 0.02-3.03 wt.% of the particle mass emitted by the pellet stove. It was present in almost all samples from this latter burning appliance. For pellets type II and III, which were made of wastes from the furniture manufacturing industry, levoglucosan was only detected during the operation at the lower level of power output. Recent studies of levoglucosan suggest that the transglycosylation process (cellulose degradation pathway) occurs at lower temperatures than previously assumed, between 150 and 350 °C (Kuo *et al*., 2008), with maximum yields at 250 ºC, regardless of plant species. Therefore, levoglucosan is not a suitable tracer for sophisticated appliances with automatically fired wood combustion in which high temperatures are reached. Thus, the high temperatures recorded in the combustion chamber of the pellet stove during the present study can explain the lower anhydrosugar content in the PM_{10} mass in comparison with more traditional appliances. Mannosan and galactosan were absent from almost all samples whether from the combustion of agro-fuels or from pellets made of wood wastes.

L/M ratios ranging from 2.3 to 10.9 and from 0.8 to 3.3 for hardwood combustion in the fireplace and woodstove were, respectively, obtained. Softwood generated an average L/M ratio of 6.0 for the fireplace, whilst a lower value of 1.3 was determined for the traditional woodstove. Clearly different ratios between biofuel categories were observed for the eco-labelled woodstove: 2.9 (softwood) and 23.7 (hardwood).

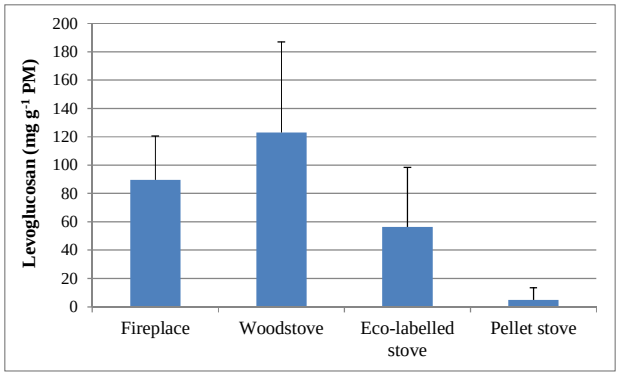

Figure 1. Levoglucosan mass fractions in particles emitted by different residential combustion appliances.

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