Influence of food surface area on $PM_{2.5}$ and particle number concentration during frying

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Introduction

The primary sources of indoor aerosols in a home are cooking and tobacco smoking (Hussein et al., 2006). Among cooking activities, frying or stir-frying have been found to be responsible for the highest particle emissions. See and Balasubramanian (2006) showed that frying compared to steaming and boiling leads to greater increase in the particle concentration. Lee et al. (2001) also found that stir-frying was a larger source of particle emissions when compared with other cooking methods. Torkmahalleh et al. (2012 and 2013) showed that cooking oils with high smoke temperature (i.e, soybean and canola oils) and additive such as sea salt, table salt and black pepper can profoundly decrease the level of $PM_{2.5}$ and particle number concentration, at certain temperature. The aim of this study is to investigate the effect of food surface area and mass during frying on $PM_{2.5}$ and particle number concentration.

Materials and Method

The experiments were conducted in an operating laboratory hood. The details of the experimental procedure were given by Torkmahalleh et al. (2012a). The experiments were conducted using tofu and soybean oil. The lab hood is separated into two sections side to side. In one section, a 1L beaker containing 200 ml of soybean oil together with a piece of tofu fully immerged in the oil was heated on a hot plate. The beaker then was moved to the other side of hood for monitoring when the oil reached around 205°C. The first particle measurement was at 185±1°C for each set of experiments since adding tofu accelerated the decrease of the oil temperature. The main variables in this experiment were the total surface area and total mass of tofu, which means that the total surface area and mass of tofu varied among three sets of experiment. Each set was replicated five times. Particle emissions were monitored approximately 0.35 m above the oil surface. After each replicate, the beaker was washed with a soap solution and rinsed with distilled water to remove any oil between experiments. A TSI (St. Paul, MN) DustTrak with a $PM_{2.5}$ inlet was used to estimate the mass concentration of particles emitted during the experiments. The sampling time for these instruments was set to 1 minute. Particle number and size distribution ranging from 10 nm to 500 nm were monitored by a MSP (Shoreview, MN) wide range particle spectrometer (WPS), for which the sampling time for each scan was set to 2 minutes.

Results and Discussion

Figure 1 shows particle mass concentrations of heating pure soybean oil and frying soybean oil together with tofu with different surface areas and masses. There are no major changes observed by adding tofu with the smaller surface area and mass values. Thus, the tofu with a relatively small size does not influence particle mass concentration substantially. However, compared to the $PM_{2.5}$ concentration from pure soybean oil only, tofu with total surface area of 108 cm^2 and mass of 75 g increases the particle mass concentration by 10 times at 185°C to around 22 mg/m^3. This result could be attributed to the large amount of vapor released from frying tofu with a large surface area. The particle mass emissions from frying pure oil and tofu decreased with decreasing temperature.

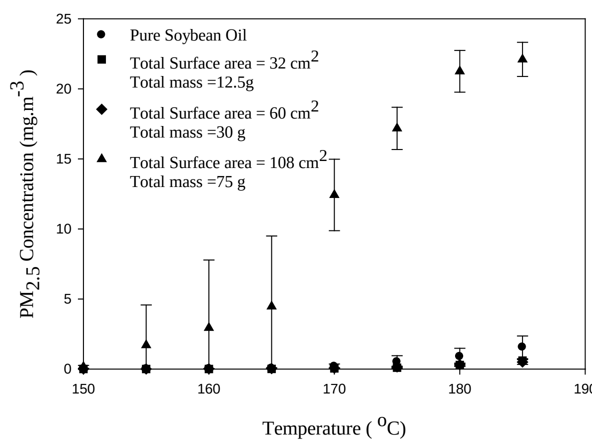

Figure 1. Mean and standard deviation of $PM_{2.5}$ concentration against temperature for soybean oil together with tofu

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