Study on air quality and trace metal contents in mangrove wood charcoal and coconut shell charcoal products during barbequing

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ABSTRACT: While charcoal is the most common fuel for barbeques, excessive exposure to charcoal smoke can disrupt our breathing systems and contribute to health risks. The objective of this study is to examine the potential health impacts during the burning of mangrove wood and coconut shell charcoals. Air emission performance was assessed for both charcoal types using indoor air quality and particulate matter instruments. Trace metal content was also tested on barbeque products. In terms of air quality, the air emitted by coconut shell charcoal produces better air quality and less particulate matter than mangrove wood charcoal. No harmful compounds were present in the cooked food samples. This research suggests that coconut charcoal should be commercialized.

Keywords: ***Indoor air quality; Mangrove; Coconut shell; Charcoal; Air pollution; Barbeque***

1. INTRODUCTION

Charcoals are widely used in many countries and the most popular in food preparation and cooking. The charcoal combustion produced a large amount of waste in fly ash, ground ash and slag after combustion. Once the charcoal is burned, it releases a variety of toxic contaminants. A few potentially cancer-causing compounds are involved in trace metal content from air emission during charcoal combustion. Emissions from biomass burning contains contaminants such as respirable particulate matter (PM), carbon monoxide (CO), nitrogen oxides (NOx), volatile organic compounds (VOC), trace metals and etc [1]. This may lead to a serious health effect and reduce body oxygen movement in the incident of exposure.

According to World Health Organization (WHO), about 4.3 million of people died each year due to indoor air pollution. Excessive exposure to charcoal cooking fumes can disrupt our respiratory systems and contribute to health risks, such as asthma, lung cancer and other serious health effects. Nitrogen and sulphur oxides irritate the lungs, causing inflammation of the respiratory tract and other more serious effects on airway blockage [2]. In this work, two types of charcoals will be evaluated namely mangrove wood charcoal and coconut shell charcoal. Mangrove wood charcoal produces a high heating value of 5404.04 cal/ gram, and low sulfur content of around 0.029% and ash content of 6.34%, therefore, it can be considered as an environmentally friendly fuel [3]. Meanwhile, coconut shell has calorific value for about 6500-7600 kcal/kg, ash content for about 1.9% and 65-75% of volatile matter and moisture [4]. The two types of charcoal will be evaluated based on their air emission through indoor air quality, particulate matter, and trace metal contents presence on the cooked food samples.

2. METHODOLOGY

2.1 Materials

Mangrove wood charcoal and coconut shell charcoal were purchased at the local market in Kuantan, Pahang and used without any modification. For the barbeque, 0.104 kg of chicken breast was used as the cooking meat.

2.2 Air quality and trace metal contents testing

The experiments were conducted during outdoor barbeque process using the food sample as shown in Figure 1. The level of Indoor Air Quality (IAQ) and Particulate Matter (PM) were measured around 15 minutes after the food cooked. Both PM and IAQ were measured by using Aeroqual Series 500 and IAQ monitor. The IAQ monitor has been setup to auto logs the value for all parameter with timer for 15 minutes. Ozone (O_3) and Total Volatile Organic Compound (TVOC) were measured using Aeroqual Series Ozone meter and Haltech VOCplus meter. The measuring devices were positioned about 1 meter above the barbeque set during testing. For trace metal content, the particles on the food samples were collected in the sampling bag for further testing using scanning electron microscopy (TM-3030 Plus, Hitachi) with energy dispersive X-ray spectrometer (SEM-EDX).

Figure 1 Outdoor barbequing of mangrove wood and coconut shell charcoals

3. RESULTS AND DISCUSSION

Table 1 summarizes the air quality results during the barbequing process. The results were compared with the standard of Industry Code of Practice for IAQ by Department of Occupational Safety and Health, DOSH [5]. Most IAQ parameters met the standard, except for air temperature and CO for both types of coal. The value of CO is highly noticeable beyond the standard guidelines (>10 ppm) which can be harmful if inhaled in huge quantities. It can reduce the level of oxygen in the human body where oxygen is transported into critical organisms via the heart and brain into the bloodstream. High amount of CO can produce dizziness, confusion, unconsciousness, and death at high levels indoor or other enclosed environments.

Based on the results, the relative humidity (RH) of mangrove wood emissions was slightly exceeded the DOSH standard which could promote pathogenic growth. Given the assessment of PM, it can be observed that the value of CO_2 for both charcoals do not exceed the standard Air Quality Guideline for PM_{10} and $PM_{2.5}$ within 24 hours mean [6]. The findings can be correlated with lower smoke generated during barbequing. Earlier studies have confirmed that these two types of coal are environmentally friendly because of their low ash content [3-4].

Table 1 Summary results of IAQ and PM

Parameters	Coconut Shell	Mangrove Wood	DOSH Standard
RH (%)	67.6	72	40 - 70
Temp. (ºC)	31	31.4	23 - 26
CO (ppm)	48.6	62.3	10
CO_2 (ppm)	326	333	1000
O_3 (ppm)	0	0	0.05
TVOC (ppm)	0	0	3
PM_{10} (mg/m^3)	0.476	0.711	50
$PM_{2.5}$ (mg/m^3)	0.953	1.683	25

Figure 2 shows SEM images of cooked food samples with percent by weight of trace metal elements. No hazardous toxicants of Group 5, mercury, lead, and gold are detected on food samples. The amount of smoke generated during charcoal firing is strongly influenced by the metal content of the charcoal ingredients, indicating that the chemical composition of the cooked food samples from the EDX study was influenced by anthropogenic and natural sources. Trace metal contents of foods cooked using the mangrove wood charcoal were arranged in descending order from highest to lowest percent by weight; C > K > O > Pt > P > Al > Cl > Ca > Mg > S > Na. The order for coconut shell charcoal is arranged as C > O > Pt > Fe > P > K > S > Ti > Ca > Al > Mg > Cl. The highest percentage of carbon produced by the combustion of mangrove charcoal can be explained by the highest fixed carbon content on raw materials, which is around 69% [3].

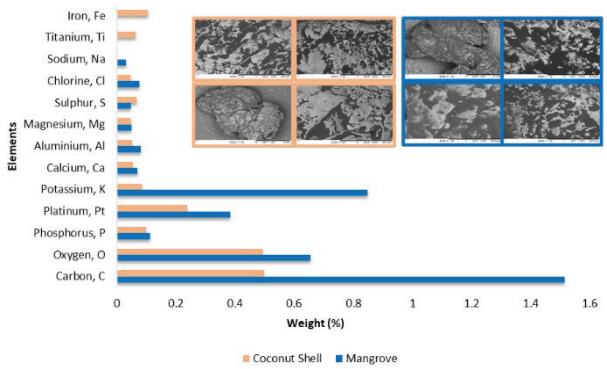

Figure 2 Trace metal content for both charcoals

4. CONCLUSION

Based on the data comparison, coconut shell charcoal is the recommended fuel for the barbeque process due to the good air quality compared to mangrove wood. Coconut charcoal emissions follow almost all air quality parameters set by DOSH and WHO standards. None of the hazardous trace elements were detected in the two food samples. Given that coconut shell charcoal has superior quality, it is ideal for manufacturers to market it all over the world rather than being wasted on the landfill site.

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