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# Deposition of Polycyclic Aromatic Hydrocarbons from Different Coconut Based Fuels in Smoke Curing of Copra

M.C.P. Rodrigo. U. Samarajeewa[1] and M.C.P. Wijeratne[2]

Post Graduate Institute of Agriculture
University of Peradeniya
Peradeniya, Sri Lanka

***ABSTRACT.*** *Presence of Benzo(a)pyrene and other carcinogenic polycyclic aromatic hydrocarbons (PAH) in copra and coconut oil has received attention over the past few years. PAH are formed during combustion of organic material used as the fuel. Even though coconut shells are used in Sri Lanka for smoke curing of copra, Philippines and Indonesia use different parts of the coconut palm, namely coconut shells, husks, leaves, petiole and wood.*

*Parts of the coconut palm were burned separately in a pilot kiln and the smoke generated was allowed to absorb in to DC/fresh coconut and sucked in to XAD-2 resin. The smoked DC/fresh coconut and XAD-2 were analyzed for the presence of PAH using HPLC.*

*The highest deposition of PAH was observed when coconut husks were used as the fuel on DC (1257±498), fresh coconut (2245±2757) and on XAD-2 resin (940±424). Coconut shells gave the least contamination of PAH on both DC/fresh coconut (189±239, 585±357) and on XAD-2 resin (80±113). Deposition of PAH on fresh coconut showed much higher values than on DC.*

## INTRODUCTION

Smoke curing of foods for preservation was practiced by man, since discovery of fire. During smoke curing, the heat in the smoke assists in drying of the foods taking away the moisture. During smoke curing some of the chemicals in the smoke get deposited and absorbed on the food surfaces. Chemically, the smoke contains more than 400 compounds (Pszczola, 1995).

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1 Department of Food Science and Technology, Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka.

2 Institute of Fundamental Studies, Kandy.

The smoke curing of coconuts is done in many countries, employing kilns of varying designs and using fuels from different woody components of plants and charcoal. As such the characteristics of the smoked foods vary widely with the type of fuel. Although smoke curing has its advantages by inhibiting the fungal growth (Arseculerathne *et al.*, 1976), another major health concern associated with smoking is the deposition of polycyclic aromatic hydrocarbons (PAH) and the nitrosoamines on the surface of the foods. Among the PAH compounds identified, a few are highly carcinogenic raising concerns on safety of smoke cured foods (Gomma *et al.*, 1993). Of them the PAH benzo(a)pyrene and dibenzo(a,h)anthracene are of high carcinogenicity.

In Sri Lanka, copra is smoke cured using coconut shells as the fuel. Other components of the coconut palm namely coconut husks, leaves, dried petiole and wood are used in kilns in other coconut producing countries in the South East Asian region.

The objective of the study was to understand the PAH deposition from different fuels during smoke drying of copra with a view to identifying means of minimizing PAH in cured products.

## MATERIALS AND METHODS

### Substrate

Desiccated coconut of fine grade, grated fresh coconut and XAD-2 resin were used as substrate to deposit/absorb PAH from smoke during curing.

### Smoking of desiccated and fresh coconut

A 200 L metal barrel (oil drum) contained a hole of diameter 14 cm on the top and openings for ventilation at the sides near the bottom served as a smoke chamber simulating a kiln. Coconut husks, dried leaves, dried petioles, wood and copra kernels were burned separately in the kiln and the smoke generated was allowed to pass through DC/fresh coconut kept on the sieve for 25 min. Burning was adjusted by altering the height to maintain a temperature of 70°C on the surface of the drying DC/grated coconut throughout the collection time.

## Adsorption of PAH in to XAD-2 resin

XAD-2 resin (styrene-divinyl benzene copolymer) was used for the adsorption of PAH. Smoke produced by burning different types of coconut based fuels was aspirated through a funnel which was placed on the top hole of the chamber used in the smoking of DC/fresh coconut. Smoke coming through the funnel was filtered using a cellulose filter with a diameter of 2.5 cm (0.2 μ). Filtered smoke was made to pass through XAD-2 resin (25 g) packed in a glass tube under suction. The glass tube containing XAD-2 resin was maintained at low temperature, by placing it inside a condenser system, with running tap water to cool the resin. Cooling was done to facilitate the condensation of smoke constituents. Before use, the resin was washed with 30% dichloromethane in hexane (40 ml) to remove any probable traces of PAH that may have contaminated the resin. A fresh filter paper was used for each trial.

After collecting smoke from different coconut based fuel sources, the resin was extracted with 40 ml of 30% dichloromethane in hexane by shaking. PAH extracted from resin was estimated by HPLC.

## Estimation of PAH

Oil from the smoked DC/fresh coconut samples (10 g) was extracted in Soxhlet with hexane (250 ml) by refluxing for 4 h. The siphon rate was 10-12 cycles/h. Hexane was evaporated from the extract in a rotavapor under reduced pressure at 65°C followed by oven drying at 70°C for 2 h. The extract of oil (0.2-0.3) g was made up to 10 ml with hexane in a volumetric flask. An aliquot of 1 ml of hexane solution was passed through a Sep-pak (Bond Elute LRC, Varian Inc.) cartridge conditioned by eluting with 2 ml of hexane. PAH were eluted with 3 ml of hexane :dichloromethane (3:1). The solvents were evaporated to dryness under a slow jet of nitrogen gas. The dry contents were dissolved in 500 ml of acetonitrile:water (3:1) for analysis by HPLC.

The HPLC system consisting of a Shimadzu model LC-6A machine containing a model SIL-6A injector, solvent delivery system (model LC-6A), a fluorescence detector (model RF-551) with 298 nm excitation filter and 439 nm emission filter was used. The reverse phase HPLC system, solvent program and peak integration parameters were controlled by a Shimadzu SCL-6A system controller and a CR-4A integrator. Samples were analyzed using Chrompack ChromSpher PAH glass cartridge column (20 cm × 3 mm i.d.).

Extracts of 30% dichloromethane was evaporated under a stream of nitrogen and dissolved in 60 ml of 30% acetonitrile in water. 50 µl of this was injected to the HPLC for the analysis of PAH.

## RESULTS AND DISCUSSION

### Deposition and generation of PAH during smoke curing

The PAH deposited on the three adsorbents desiccated coconut, fresh coconut and XAD-2 from different fuels during burning are given in Table 1 and 2. Coconut husks always generated the highest PAH which was at least 5 fold higher than what is generated by shells.

**Table 1. PAH of solvent extracted oil from fresh and desiccated coconut smoke cured using different fuels.**

| Absorbent | Fuel | | PAH (µg/kg) | | | |
|---|---|---|---|---|---|---|
| | | | BaP | Light | Heavy | Total |
| Fresh | Husks | Mean | 25 | 2201 | 45 | 2245 |
| | | SD | 41 | 2705 | 52 | 2757 |
| DC | Husks | Mean | 30 | 1201 | 57 | 1257 |
| | | SD | 10 | 522 | 27 | 498 |
| DC | Leaves | Mean | 11 | 354 | 112 | 466 |
| | | SD | 1 | 37 | 39 | 2 |
| Fresh | Leaves | Mean | 20 | 551 | 33 | 585 |
| | | SD | 14 | 344 | 24 | 357 |
| DC | Shells | Mean | 5 | 182 | 7 | 189 |
| | | SD | 6 | 229 | 11 | 239 |
| DC | Trunk | Mean | 5 | 285 | 4 | 289 |
| | | SD | 6 | 261 | 6 | 267 |
| DC | Frond | Mean | 9 | 173 | 26 | 199 |
| | | SD | 1 | 8 | 16 | 8 |
| DC | Copra | Mean | 12 | 302 | 12 | 314 |
| | | SD | 4 | 157 | 4 | 161 |

DC = Desiccated coconut
Fresh = Fresh coconut
BaP = Benzo(a)pyrene

The absence of any detectable concentrations of PAH from shell in some experiments is notable and indicates the possibility of keeping PAH at low concentrations on smoke curing. This probably explains the relatively low PAH concentrations observed in copra from Sri Lanka compared to what is reported in Indonesia and Philippines where husks form a part of the fuel. Production of Benzo(a)pyrene was also high (30 µg/kg) when coconut husks were used as the fuel. Desiccated coconut smoked using coconut husks showed a higher mean value (1257 µg/kg) of total PAH compared to use of coconut shells showing 189 µg/kg of total PAH only (Table 1 and Figure 1). The above observations were further improved by the results of the experiment using XAD-2 resin (Table 2). A knowledge of the composition of the fuel material used is essential in considering the production of PAH coconut husks contain higher amounts of lignin (45%) than coconut shells (36%). The production of high PAH is probably related to the high amount of lignin present.

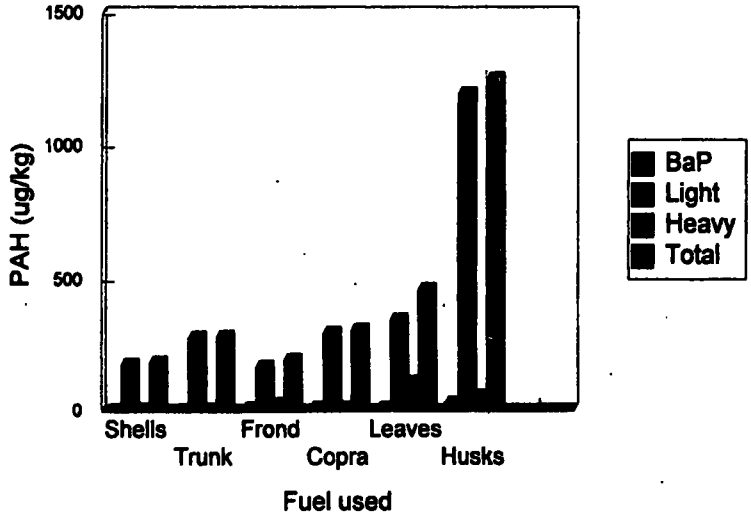


**Figure 1.** **PAH of solvent extracted oil from desiccated coconut smoke cured using different fuels.**
[Note: BaP = Benzo(a)pyrene]

**Table 2. PAH absorbed by XAD-2 resin from smoke of different fuels when passed for 15 min.**

| Fuel | | PAH ($\mu$g/kg) | | | |
|---|---|---|---|---|---|
| | | BaP | Light | Heavy | Total |
| Shells | Mean | 0 | 80 | 0 | 80 |
| | SD | 0 | 113 | 0 | 113 |
| Husks | Mean | 1 | 800 | 140 | 940 |
| | SD | 0 | 395 | 28 | 424 |
| Wood | Mean | 0 | 140 | 20 | 160 |
| | SD | 0 | 28 | 28 | 0 |
| Copra | Mean | 0 | 20 | 20 | 100 |
| | SD | 0 | 27 | 28 | 85 |

Drying of copra is not the only industry that employs smoke curing. Preparation of Maldive fish employs kilns similar to copra kiln and use much coconut husks and leaves as fuel. It is important to only use coconut shells, in smoke curing practices for drying of foods in order to keep the PAH concentration at the minimum level.

## CONCLUSIONS

Production of PAH varies widely with the type of coconut based fuel used. Coconut husks produced the highest amount of PAH while the coconut shells produced the least.

## ACKNOWLEDGEMENTS

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