RTI Author Awards Series

Mutagens from Heated Chinese and US Cooking Oils

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The lung cancer incidence in Chinese women is among the highest in the world, but tobacco smoking accounts for only a minority of the cancers. Epidemiologic investigations of lung cancer among Chinese women have implicated exposure to indoor air pollution from wok cooking—the volatile emissions from unrefined cooking oils are mutagenic.

In collaboration with investigators at the National Cancer Institute, we conducted a study to identify and quantify the potentially mutagenic substances emitted from a variety of cooking oils heated to the temperatures typically used in wok cooking. Several cooking oils and fatty acids were heated in a wok to boiling, at temperatures (for the cooking oils) that ranged from 240 degrees Centigrade to 280 degrees Centigrade (typical cooking temperatures in Shanghai, China). We tested unrefined Chinese rapeseed oil, refined U.S. rapeseed oil (known as canola oil). Chinese soybean oil, and Chinese peanut oil in addition to linolenic, linoleic, and eurucic unsaturated fatty acids. Condensates of the emissions were collected and tested in the Salmonella mutation assay using two test strains of the bacterium *Salmonella typhimurium*. Volatile decomposition products also were tested using gas chromatography and mass spectroscopy to detect and identify the organic chemicals produced from the cooking oils. The chemical class, aldehydes, was measured using high-performance liquid chromatography and UV spectroscopy.

1,3-Butadiene, benzene, acrolein, formaldehyde, and other related compounds, all implicated in various acute and chronic diseases (e.g., cancer) were qualitatively and quantitatively detected, with emissions tending to be highest for unrefined Chinese rapeseed oil and lowest for peanut oil. The emission of 1,3-butadiene was approximately 22-fold higher from heated unrefined Chinese rapeseed oil than from heated peanut oil, and the emission of benzene was approximately 12-fold higher. Lowering the cooking temperatures or adding an antioxidant, such as butylated hydroxyanisole, before cooking decreased the amount of these volatile emissions. Among the individual fatty acids tested, heated linolenic acid produced the greatest quantities of 1,3-butadiene, benzene, and acrolein.

Separately, the mutagenicity of individual volatile emission condensates was correlated with linolenic acid content: condensates from heated linolenic acid, but not linoleic or erucic acid, were highly mutagenic.

This study, combined with experimental and epidemiological findings, suggests that high-temperature wok cooking with unrefined Chinese rapeseed oil may increase lung cancer risk. This study indicates methods, such as the use of different oils or of lower cooking heat, that may reduce that risk. The common use of wok cooking in China might be an important but controllable risk factor in the etiology of lung cancer. In the United States, where cooking oils are usually refined for purity, additional studies should be conducted to further quantify the potential risks of typical American methods of cooking.