Analysis of Furan in Different Foodstuffs Using Gas Chromatography Mass Spectrometry

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Furan is the parent compound of a class of derivatives collectively known as furans. It is a colorless, volatile liquid used in some segments of the manufacturing industry. Derivatives of furan are for example used as flavouring agents in food and tobacco products. The nonderivatised furan has been identified previously in a small number of heat-treated foods, including coffee, canned meat, baked bread, cooked chicken, sodium caseinate, hazelnut filberts, soy protein isolate, hydrolysed soy protein, rapeseed protein, fish protein concentrate, and caramel [1–4]. In May 2004 the Food and Drug Administration (FDA) reported the finding of very low levels of furan in a number of foodstuffs that undergo heat treatment such as canned soups, sauces, beans and pasta meals as well as in jars of baby foods [5]. Concentrations ranged from nondetectable (< 2 μg/kg) to approximately 100 μg/kg.

Exactly how furan forms in food is unknown. Early studies indicate that there are probably multiple mechanisms of furan formation. Heating is an important contributing factor, but it may not be the only pathway. According to Maga [1] the primary source of furans in food is a thermal degradation and rearrangement of organic compounds, particularly carbohydrates through a Maillard reaction. Nonderivatised furan was found after thermal degradation of glucose, glyceraldehydes, D-erythrose, pentosans, hexoses, and polysaccharide as well as in a lactose-casein browning system. According to Forsyth *et al*. [6] furan can be formed by thermal oxidation of polyunsaturated fatty acids (linoleic, linolenic) via peroxidation and ring closure as well as by decomposition of ascorbic acid derivatives particularly dehydroascorbic acid and isoascorbic acid.

Furan is considered potentially carcinogenic to humans by the International Agency for Research on Cancer (IARC), based on studies in laboratory animals at high exposures. The concern is whether furan may also cause cancer in humans through long-term exposure to very low levels of furan in foods. Therefore, more data and information are requested for evaluating the risk posed by the presence of furan in food.

In our study furan was analysed after headspace sampling by gas chromatography mass spectrometry (GC-MS) according to the FDA method [7]. Quantification was carried out using deuterated furan (D4-furan) as internal standard (IS). Differing from the FDA method, quantification was performed by simply using the integrated response ratio for furan/D4-furan and the amount of IS. According to the FDA method furan is quantified using the standard addition method.

Shortly, the entire food container was chilled in a refrigerator for about 4 h. The chilled content was transferred to a beaker immersed in an ice bath. The sample was homogenised in a mixer under ice cooling. Five g of the homogenised sample are transferred to a headspace vial, diluted with water, fortified with IS, and analysed by automated headspace GC/MS.

Comparison of the quantification data using the one point estimation and the standard addition method according to the FDA method showed a good correlation.

Furan levels of different foods varied between not detectable (< 3 μg/kg) and 200 μg/kg. Higher levels (20–200 μg/kg, median of 54 μg/kg, n = 18) were determined in potato crisps, crackers and crisp bread. Significant levels were also analysed in cookies (< 5–35 μg/kg, median of 9 μg/kg, n = 11) and in minced meat (< 5–100 µg/kg, median of 20 µg/kg, *n* = 9) while French fries were found to contain no significant levels (3–4 µg/kg; *n* = 4). Highest levels were analysed in roasted coffee. In the coffee powder up to 2500 µg/kg can be found. However, only a small amount is transferred into the brewed coffee (10–150 µg/kg). This may be due to the small water solubility and the low boiling point (31°C) of furan.

In conclusion the obtained data confirm the presence of furan in different processed foods. The finding of furan in special heated products like coffee, potato crisps and cookies points out a link between acrylamide and furan formation (i.e. through Maillard reaction) since the affected food products were also known to contain acrylamide. Positive findings of furan in meat are in accordance with findings of Person and von Sydow [3]. They have shown that furan formation is favoured in meat with higher fat content. This indicates another important pathway of furan formation, i.e. the thermal oxidation of lipids.

References

[1] Maga J.A. (1979): CRC Critical Reviews in Food Science and Nutrition, Furans in Foods: 355.

[2] NRC (National Research Council) (1994): Spacecraft Maximum Allowable Concentrations for Selected Airborne Contaminants, Vol. 4., appendix B 14, National Academy Press, Washington, DC.: 307.

[3] Persson T., von Sydow E. (1973): J. Food Sci., **38**: 377.

[4] Stoffelsma J., Sipma G., Kettenes D.K., Pypker J. (1968): J. Agric. Food Chem., **16**: 1000.

[5] U.S. Food and Drug Administration. http://www.cfsan.fda.gov/~dms/furanqa.html

[6] Forsyth D.S., Becalski A., Casey V., Seaman S., Pepper K., Rejeb S.B.: http://www.fda.gov/ohrms/dockets/ac/04/slides/2004-4045s2-04-Forsyth.pdf

[7] U.S. Food and Drug Administration. http://www.cfsan.fda.gov/~dms/furan.html