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Furan in Foods on the Swiss Market – Method and Results

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Introduction

The US Food and Drug Administration (FDA) has published a report on the occurrence of furan in foodstuffs on Mai 7, 2004 (1). Furan has been found in a widespread variety and partially in important amounts in processed and thermally treated food. The presence of furan is a potential concern because of indications of liver toxicity in experimental animals. Furan induces tumors in animal assays; most remarkable is the induction of hepatic cholangiocarcinomas in rats and mice. The International Agency for Research on Cancer (IARC) has classified furan as "possibly carcinogenic to humans" (Group 2b). The process which leads to the presence of furan in food is not known at present. Investigations so far undertaken point to food processing as inducing factor. The possible formation of furan by oxidation of polyunsaturated fatty acids at high temperatures, and the decomposition of ascorbic acid derivatives was mentioned by Health Canada (2). The available data show that especially canned and jarred food give rise to elevated furan concentrations.

In order to evaluate the health risk, it will be necessary to carefully collect experimental data. In this article we present our analytical method for the determination of furan in foodstuffs.

Sampling and Method

Based on the indications of FDA, similar products and those typical for the Swiss market, were investigated in order to assess their furan content.

For analysis an amount of 30 g sample and 30 ml cold water (Nanopur quality) were homogenized (Polytron, Kinematica, Littau, Switzerland) in a beaker and a 10 g – aliquot transferred immediately in a headspace vial containing 4 g NaCl (Fluka, Buchs, Switzerland) and vortexed vigorously. From liquid samples a 10 g – aliquot can be directly withdrawn. Subsequently, 100 µL of a working solution of furan-D_4 (Acros, Belgium, c=5 ng/µL in Nanopur-water) were added by a gas tight 100 µL syringe (Hamilton USA) and the vial immediately sealed. The working solution was prepared daily from a stock solution of furan-D_4 (c=2.5 mg/ml in

methanol). Usually, the samples were precooled and the sample handling was carried on in a cold room at about 4 °C.

Furan was then detected through headspace – GC-MS. The procedure work off was accomplished by an automated PAL-autosampler (CTC, Zwingen, Switzerland) with headspace equipment as follows: Equilibration time for samples was 10 minutes at 80 °C under vigorous shaking, subsequently injection of 1000 µL with thermostated syringe (70 °C), split 10:1. The injector temperature was held at 200 °C and the injected gas volume chromatographed on a PlotQ – capillary column (J&W, 30m, 0.25mm i.d., 20µm phase thickness) in a Thermo Finnigan Trace GC with subsequent ion detection through a PolarisQ ion trap mass spectrometer (Thermo Finnigan, USA). The temperature program for the capillary column was started at 50 °C, raised after 1 min. with 20 °C per min. up to 260 °C and held during 2.5 min at 260 °C. The carrier gas flow was maintained at 1.0 ml He(60) in constant-flow mode.

Quantitation was achieved through addition of furan-D_4 as internal standard. For data analysis the ion traces m/e=68 (furan) and 72 (furan-D_4) were integrated and the resulting ratio corrected for molar equivalent (furan=1.06×furan-D_4) in order to determine the furan content of the sample.

While the methodology of the FDA proposes quantification using a standard addition curve of furan-fortified samples additionally to the determination of the furan/furan-D_4 response, we could not find any gain in precision compared with only tracing the furan/furan-D_4 ratio for quantitation as proposed above.

Robustness of the method was tested by addition of each ca. 20 % NaCl, fat (mayonnaise), proteins and sugar to a coffee sample, respectively. While the addition of mayonnaise reduced recovery by around 80 %, no interfering matrix effects on the value of the furan/furan-D_4 ratio could be identified.

In order to validate the method, six-fold determinations of an infant formula from six different jars (mean value, standard deviation=88±11 µg/kg furan, relative standard deviation=13 %), of the same infant formula but from one selected jar (mean value, standard deviation=78±5 µg/kg furan, relative standard deviation=6 %) and of coffee (drink) (mean value, standard deviation=69±6 µg/kg furan, relative standard deviation=8 %) were performed.

The limit of quantitation is matrix dependent and was usually in the range 0.5 to 2 µg/kg.

Results and Discussion

Table 1 gives an overview on the found furan content of the samples. Values are given in µg/kg.

Jarred baby food (n=102, min=1, max=153, median=12 µg/kg furan) were grouped according to their main components into the varieties "meat" (n=8, min=3, max=6, median=4 µg/kg furan), "fruits" (n=45, min=1, max=16, median=3 µg/kg furan) and "vegetables" (n=49, min=4, max=153, median=35 µg/kg furan), respec-

tively. Especially baby food jars containing mainly vegetables had significantly elevated furan values, compared to baby foods with other formulations.

Table 1
Furan values for the listed foods are given in µg/kg

Sample description	*Minimum*	*Maximum*	*Median*	*n*
Baby Food in small glass jars	1	153	12	102
Fruit and vegetable juices for babies and young children	1	40	3	4
Coffee (drink)*	13	146	74	9
Hot chocolate and malt beverage*	<2	<2		2
Canned or jarred vegetables	<2	12	3	15
Canned soups	19	43		2
Canned fruits*	<1	6		2
Tin containing meat	4	4		1
Tin containing meat and pasta	14	14		1
Sugo, tomato and Chili sauces (with or without meat)	<4	39	6	13
Soy sauce, hydrolyzed vegetable protein	18	91	50	7
Vegetables, fresh	<1	<2	<1	7
Bread and toast*	<2	30	<2	7
Whole milk UHT*	<0.5	<0.5		1
Plum beverage*	6	6		1
Beetroot juice with fruit juices (organic)*	1	1		1
Potato flakes for mashed potatoes (flakes, not prepared)	<5	<5		1

*=ready to eat
n=number of samples

The listed data from table 1 is not concluding, i.e. one has to expect that further foods contain furan, as long as mechanisms of formation and required conditions are not known. Further, it must be stressed that tabulated data are not directly appropriate to calculate intakes from. Some preliminary tests let us conclude that furan intakes from ready-to-feed products for babies tend to be overestimated, since the can/jar content is usually warmed and stirred before use, which leads to furan losses in the order of magnitude of factor 2 to 5.

In coffee powder (ground beans) furan contents were found to be in the range 1000 to 2700 µg/kg (n=3). We assume that the furan content in coffee (drink) is underestimated using our analysis method, since detected values decrease rapidly from the point on the coffee is freshly prepared until to the moment of sampling. Coffee is mostly drunk freshly prepared and hot, after all.

Note Added in Proof

From further experiments we assume that carbohydrates could probably be the most important precursor for furan formation. For example if we heat pure crystalline sugar (caramelization of sucrose) we get relevant amounts of furan. Also the dry heating of wheat flour type 405 produces high amounts of furan.

Summary

The presented method enables efficient detection of furan in a widespread variety of food. The determined furan values confirm the findings of the FDA. However, the achieved data are at the present state unsuitable to estimate consumer expositions, since most of the herein listed foods undergo further treatment such as heating before consumption. Further, the presented list of products containing furan might not be complete, i.e. additional sources of furan could turn up in the future.

Zusammenfassung

Die hier vorgestellte Methode hat sich als geeignet erwiesen, um rasch Auskunft über den Gehalt an Furan in einer breiten Palette von Lebensmitteln zu erhalten. Die gefundenen Furan-Werte bestätigen die Befunde der FDA. Die Daten sind jedoch nicht für Expositionsabschätzungen geeignet, da die meisten Produkte vor dem Verzehr noch erhitzt oder anderweitig verändert werden. Ausserdem ist die Liste der furanhaltigen Lebensmittel nicht abschliessend, d.h. es ist anzunehmen, dass noch nicht alle möglichen Furan-Quellen erkannt wurden.

Résumé

La méthode décrite permet de déterminer d'une manière efficace le furane présent dans une large palette de denrées alimentaires. Les valeurs trouvées confirment les résultats de la FDA. Cependant, celles-ci ne peuvent pas être utilisées pour déterminer une exposition des consommateurs au furane car les denrées alimentaires analysées subissent, dans la plupart des cas, un traitement supplémentaire avant d'être consommées. La liste des denrées alimentaires analysées n'étant pas exhaustive, d'autres aliments pourraient dans le futur montrer la présence de furane.

Key words

Furan, headspace GC-MS, Swiss market food products

References

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