SCIENTIFIC REPORT submitted to EFSA

Furan in heat processed food products including home cooked food products and ready-to-eat products[1]

Prepared by Arvid Fromberg, Sisse Fagt and Kit Granby
DTU– National Food Institute

Abstract

Furan has been found to be formed in canned, jarred and roasted food items and high levels of furan have been found in coffee. As furan is carcinogenic in animal experiments attention has been drawn to the presence in commercial and home-cooked foods. In the present study performed by the the National Food Institute at the Technical University of Denmark, the formation of furan in home cooked foods as well as the stability of furan during cooking, saving and reheating of the meals are presented. Home cooked foods having high levels of carbohydrates are most likely to form furan for instance are furan levels found in toasted bread slices, French fries and crisps correlated with the browning level. As worst case scenarios, foods were home cooked using canned ingredients which contained furan. However, this did not lead to elevated levels of furan in the prepared home cooked foods. For ready-to-eat foods with an initial level of furan, cooking reduced the level of furan in the food to about half the original content probably due to evaporation of furan during heating. Nevertheless furan is relatively stable in heated foods left for cooling where the losses of furan were insignificant.

Samples of breakfast cereals and dry bread products have relatively high levels of furan and also bakeware like biscuits, cookies; snacks like crisps, popcorn etc. and sundried fruit and vegetables like raisins, tomatoes contained furan. An estimate of the furan intake for Danish adults revealed that 95% was from consumption of coffee, whereas the food group contributing most to Danish children's intake of furan is the breakfast cereals.

Summary

Furan has been found to be formed in canned, jarred and roasted food items and high levels of furan have been found in coffee. As furan is carcinogenic in animal experiments, attention has been drawn to its presence in commercial and home-cooked foods. In the present report results of the

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investigation of the formation of furan in home cooked food are presented as well as the stability of furan during cooking, saving and reheating of the meals.

Several of the home cooked foods have been tested for their ability to form furan during the preparation of the meals. Home cooked foods rich in carbohydrates are most likely to form furan, probably due to Maillard browning reactions of the food. Furthermore, high levels were found in toasted bread slices (e.g. 83 µg/kg furan for dark toasted bread) and this was correlated to the browning level. For the worst case scenarios, foods were home cooked using canned ingredients with contents of furan. However, this did not lead to significantly increased levels of furan in the prepared home cooked foods.

For ready-to-eat food with an initial level of furan, cooking reduced the level of furan in the food to about half the initial content probably due to evaporation of the furan during heating. Nevertheless furan is relatively stable in food items and the loss of furan from heated ready-to-eat foods left for cooling may be disregarded because the levels do not decrease significantly until the food is reheated.

A number of dried fruits were analysed, revealing large differences between the individual samples. It is unclear why relatively many sundried fruit and vegetable products like raisins, tomatoes, dried bananas contained furan. Furthermore samples of breakfast cereals and dry bread products were investigated and relatively high levels up to 0.4 mg/kg of furan were found in the products. Also, dry bakeware like rusks, rasps, biscuits, rice cakes, cookies, crispbread and snacks like crisps, salted snacks, popcorn, peanuts etc. contained furan.

An estimate of the furan intake for adults revealed that 95% was from consumption of coffee. This estimate was, however based on the Danish consumption data and as Danes, like other adults from Northern Europe, have an average consumption of more than 0.6 L of coffee, the contribution to the total intake might be high. For Danish children the food group contributing most to the intake of furan is the breakfast cereals. For children with a high consumption of breakfast cereals (the 95 percentile) and a mean consumption of other foods the furan exposure from breakfast cereals account for about 2/3 of the total exposure. The estimate of the total median furan exposure for adults (15-75 years old) was 33.5 µg/day and for children (4-6 years old) 1.1 µg/day.

Key words: Furan, home cooked food, ready-to-eat products, process contaminants, children's intake, home-cooked foods, coffee, ready-to-eat foods, crisps, breakfast cereals

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Furan in heat processed food products including home cooked food products and ready-to-eat products

Report of the EFSA CFP/EFSA/DATEX/2007/03 project

By Arvid Fromberg, Sisse Fagt and Kit Granby

Laboratory and work assistance by

Laboratory technician Vibeke Balswel
Laboratory technician Vera Lykkerask
Associate Professor Franco Pedreschi, Universidad de Santiago de Chile
Clinical dietician Karin Hess Ygil
Secretary Anne Gant

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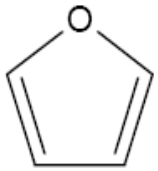
The National Food Institute
The Technical University of Denmark
Mørkhøj Bygade 19
DK-2860 Søborg, Denmark
Phone +45 35 88 70 00
Fax +45 35 88 70 01

Introduction

Furan is a cyclic ether with a boiling point of 31.4°C. Furan has been identified in a number of food products (Maga, 1979), especially jarred and canned food items that undergo heat treatment in a sealed container, but furan has also been detected in food items such as meats, beer and nuts. (FDA 2004).



Since the European Food Safety Authority (EFSA) in their report on furan in food (EFSA, 2005) has expressed their opinion on the carcinogenicity of furans probably attributable to a genotoxic mechanism special attention has been given to the formation of furan in foods.
The present project consists of four sub-projects with individual objectives. The overall objective of the four sub-projects are to collect data regarding the levels of furan in a range of different foods and to study the effect of home cooking and preparation on such levels in order to insure food safety.

For sub-project one the objective was to describe the occurrence of furan in home cooked foods by evaluating the influence of different cooking procedures used for preparation of various food items and composite foods. Home cooked food can be prepared by several methods following various recipes. The aim of this sub-project was to locate the preparation methods and the food items most likely to result in high furan levels, especially focusing on food products or dishes highly consumed by the European population.

The objective of sub-project two was to evaluate the effects on furan concentration of heating ready-to-eat foods. In this sub-project the objective was to assemble the influence of heating and reheating of ready-to-eat foods. During preparation of ready-to-eat products a concentration step is often used in order to gain the desired consistency and flavour of the product. During this procedure or in the following canning or jarring process furan is likely to be formed. The objective was to describe the processes resulting in the highest furan concentrations in the ready-to-eat foods.

In sub-project three the objective was to describe the changes in furan concentrations due to heating. Experiments were carried out in order to investigate different heating procedures including different heating temperatures and different heating techniques for example heating in a pot vs. microwave heating, in order to determine the stability of furan under these conditions.

The objective of sub-project four was furan evaporation or elimination from foods over time. In sub-project four samples were coordinated with samples from the other sub-projects, as the objective was to evaluate the changes in furan levels over time. Sub-samples from sub-project 1-3 were therefore analysed after the samples has been left for different times. As furan is highly

volatile furan concentrations might change if the heated food product is left to stand after preparation. Therefore it is important to determine these effects, as initial data have shown that 10 minutes after brewing coffee a strong reduction of the furan level was observed in this beverage as result of its high volatility (EFSA 2005). However at the same time it is important to determine the temperature of the product, as consumers are not likely to consume for example cold coffee.

Previous studies on the formation of furan and the effect of interaction with can coatings revealed no interaction with the cans and their coating (Hasnip *et al.* 2006). When comparing different heating techniques, differences were observed between heating in pot and microwave oven heating (Roberts *et al.* 2008). In most cases the furan level decreased when heating in a pot, but this was not always the case when heating in a microwave oven.

Several compounds may be precursors of the furan formation. In model systems furan and methylfuran were formed from heating of ascorbic acid (Limacher *et al.* 2007). However the mechanisms leading to the formation of furan is not fully understood. Limacher *et al*. suggested the mechanisms illustrated in the Figure 1 below (from Limacher et al. 2007).

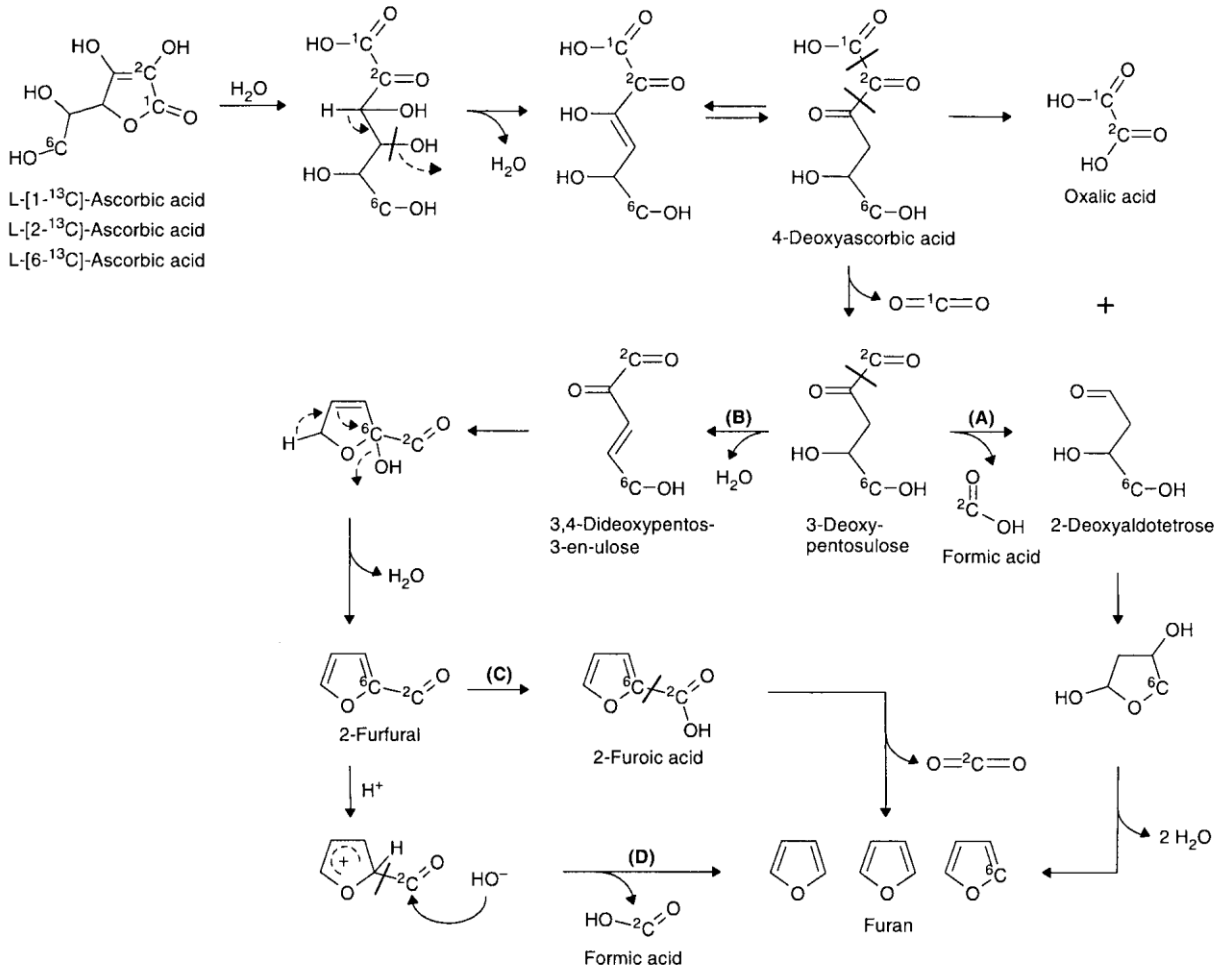


Figure 1. Formation of furan and methylfuran from ascorbic acid [from Limacher *et al.* 2007]

Furan may be formed from ascorbic acid, sugars, carbohydrates, amino acids and poly unsaturated fatty acids as illustrated in the figure 2 below (from Vranová & Ciesarová, 2009)

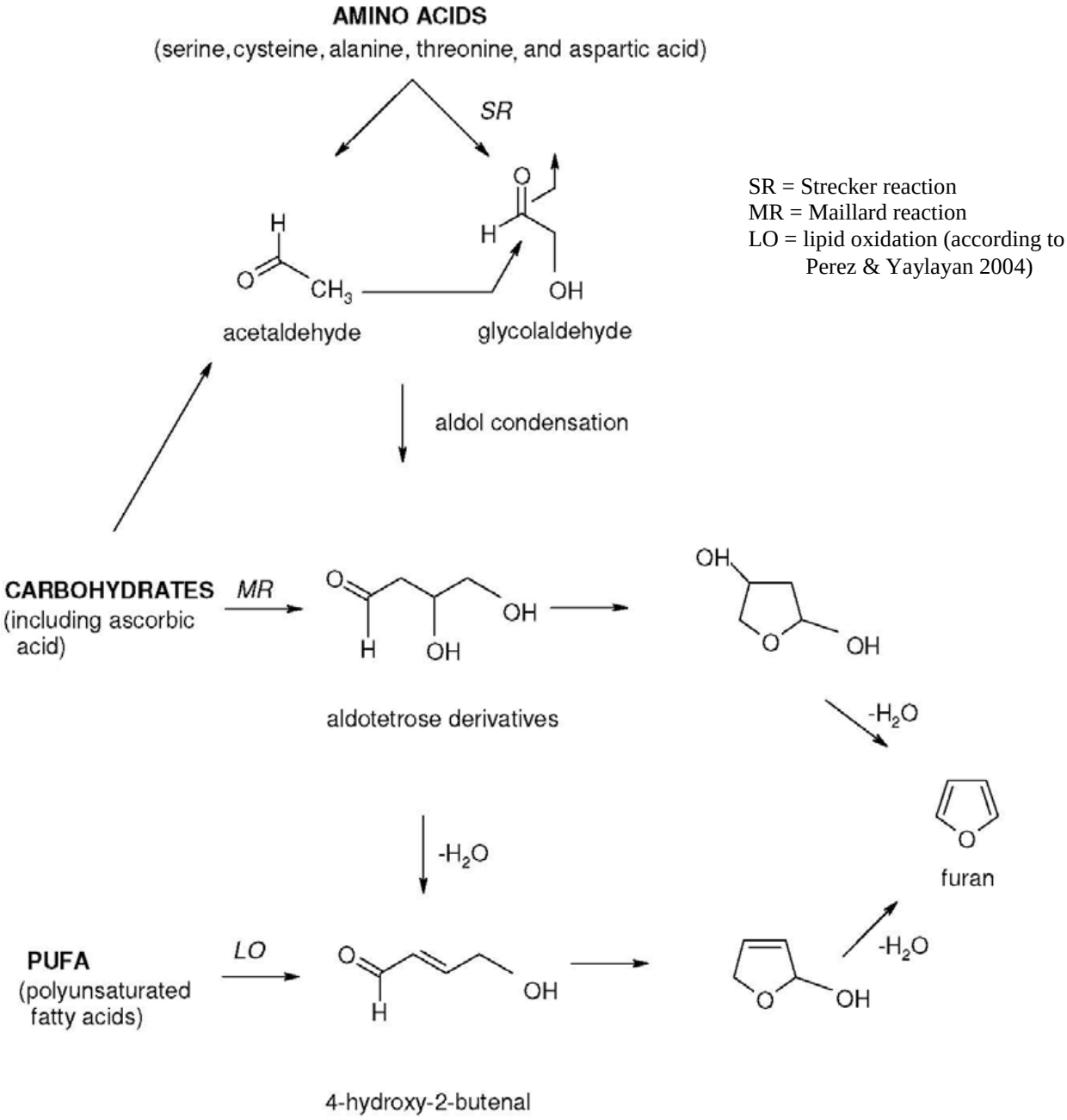


Figure 2. Proposed pathways of formation of parent furan from three main groups of sources, i.e. amino acids, carbohydrates and polyunsaturated fatty acids [From Vranová & Ciesarová 2009]

The reviews of Vranová & Ciesarová (2009) and Crews & Castles (2007) describe multiple pathways for the formation and occurrence of furan. As one of the major partway are the thermal degradation or Maillard reaction of reducing sugars; thermal degradation of some of the amino

acids and thermal oxidation of ascorbic acid and poly-unsaturated fatty acids as illustrated in Figure 2 above.

When choosing the analytical method for analysing foods content of furan special attention should be focused on the methods equilibration temperature (see Wenzl et al. 2007). d_4-furan has been found to be a suitable internal standard (IS) for the determination of furan in foods (Crews *et al.* 2007).

Materials and methods

Background for deciding on potential recipes leading to furan formation.
Department of Nutrition, National Food Institute has developed a recipe database with potential furan containing dishes which was used as a platform for analysing furan in commonly eaten freshly prepared home cooked dishes. The recipes have been chosen on basis of knowledge upon potential furan containing ingredients after heating (Zoller et al, 2007) as well as knowledge on dietary habits in the European region (Elmadfa & Weichselbaum, 2005; Fagt et al, 2008; Debacker et al, 2007, Männistö, Ovaskainen & Valsta, 2003). The recipes were chosen upon knowledge of the commonly eaten dishes in Denmark, but resemble in their basic ingredients and preparation form also dishes that are eaten all over Europe. For instance is ragu or sauce Bolognese with its main constituents: minced meat and tomatoes fried and boiled into a sauce, a dish prepared and eaten in many European countries. Also pancakes, mashed potatoes, tomato soup, fish cakes etc. are eaten in many European countries with minor variations in the recipes. It has not been considered necessary to include recipes from other countries as long as the basic ingredients and preparation methods are almost the same in different countries. All chosen recipes contain some form of heating and where possible the ingredients most likely to form furan have been selected. For instance, canned tomatoes have been chosen instead of raw tomatoes in several dishes, because of the possible furan content in canned foods.

While some recipes are chosen because they are commonly eaten in Europe, others are chosen because the literature has shown possible furan containing ingredients or preparation forms connected to furan formation. For instance caramelized potatoes is a dish eaten in Denmark, but due to the possible furan forming ingredients and preparation (sugar heated to high temperature) we included this recipe as well.

The Department of Nutrition has chosen recipes of homemade food to cover dishes with possible furan containing ingredients. The ingredients and the preparation procedure are chosen from recipes in commonly used cookbooks in Denmark. The main source of recipes has been from the popular cookbooks (Fogt, Kastberg & Haveman, 2007; Siesbye & Kirkegaard, 1989; Thomsen, 1985).

The main part of the recipes are using an electrical cooker as the heating source, but some dishes are microwave heated (oatmeal porridge) and others oven baked (chicken dish, bread and buns).

Table 1. Main ingredients and preparation procedure in selected recipes (main meals or porridge)

Recipe	Canned	Vegetables	Meat/poult	Fish	Milk/dairy	Egg	Cereals	Comments on ingredients and preparation
Oatmeal porridge[1]							●	Oats heated by cooking (oats are steamed, dried and toasted)
Oatmeal porridge in microwave oven[1]							●	Oats heated by microwave cooking (oats are steamed, dried and toasted)
Tomato soup[1]	●	●						Canned tomatoes and onion
Minestrone[1]	●	●	●					Canned tomatoes and several vegetables
Fish meatballs[1]				●		●		Minced fish
Ragu/Sauce Bolognese[1]	●	●	●					Minced meat, canned tomatoes and tomato puree, vegetables
Gullasch[1]	●	●	●		●			Beef, canned tomatoes
Meat balls[1]			●			●		Minced meat
Wok fried pork with vegetables[1]	●	●	●					Pork fried in wok with canned vegetables and soy sauce
Omelette[1]						●		Very traditional dish eaten all over Europe

1. Fogt *et al.* 2007.

Table 2. Main ingredients and preparation procedure in selected recipes (side dishes or desserts)

Recipe	Vegetables	Fruits	Potatoes	Milk/dairy	Egg	Cereals	Sugar	Comments on ingredients and preparation
Potatoes baked with cream[1]	●		●	●				Potatoes baked in oven with milk/cream
Sweet sour potatosalad[1]	●		●					Boiled potatoes with acidic marinade
Caramelised potatoes[1]			●				●	Boiled potatoes caramelised
Mashed potatoes[1]			●	●				Cooked and mashed potatoes added milk
Pancakes[1]				●	●	●		Egg, flour and milk
Orange sauce[1]		●					●	Citrus fruit and sugar boiled
Lemon sherbet[1]		●					●	Citrus fruit and sugar frozen
Cream of citrusfruits[2]		●		●	●		●	Citrus fruit, egg and milk heated and cooled
Compote of fruits[3]		●					●	Fruit and berries
Butterscotch (caramel) sauce[2]				●			●	Caramelised sugar
Apple pie[1]		●				●	●	Apples and wheat flour
Apple cake, Danish[1]		●				●	●	Apples and bread crust (bread baked twice)
Syrup cake[4]						●	●	Heated sugar which is reheated when baked
Cookies[5]						●	●	Oats, wheat flour, brown sugar and nuts baked
Wheat bread[1]						●		Eaten all over Europe
Wheat buns with raisins[1]		●				●		Buns have a bigger surface than bread. Can be added dried fruits

1. Fogt *et al.* 2007. 2. Anon (1972). 3. Siesbye & Kirkegaard (1989) 4. Thomsen (1985). 5. Ygil (2008).

Preparation of the home cooked food products
The home cooked food products were prepared according to the recipes provided by Department of Nutrition, The Technical University of Denmark. All recipes are described in Annex 1 in this report. The recipes were selected to cover at broad range of home cooked foods including starters, main dishes, desserts, bread, fruits etc. as described above.

Kitchenware
Foods were prepared using normal kitchenware, including electric cooker (Siemens), microwave oven (Panasonic (NN-E252W, 800W), Schou toaster (724055, 750W), Braun electric kettle (WK210, 2200W) and a French press cafetière to brew coffee.

Sample preparation
The analytical method used is based on headspace sampling and detection using gas chromatography – mass spectrometry (GC-MS) via isotope dilution using d_4-furan.

Chemicals
Furan (>99%) was purchased from Sigma-Aldrich (Steinheim, Germany). d_4-furan (98 atom% D) was purchased from Isotec (Ohio, USA). Methanol was purchased from Rathburn (Walkerburn, Scotland) and NaCl from Merck (Darmstadt, Germany).

Instrumentation and chromatographic conditions
Furan was determined by gas chromatography – mass spectrometry (GC-MS) from Agilent fitted with a CTC CombiPAL static headspace autosampler. The injection volume was 1 ml. The syringe was heated to 70°C and the sample vial was heated at 60°C for 30 min.

For the injection, 1 mL of the headspace from a 10 mL headspace vial was injected splitless on an Agilent gas chromatograph-mass spectrometer. A 15 m x 0.32 mm x 20 µm HP-Plot Q column was used. The He flow was 1.7 mL/min. Oven: 50°C (1 min.), temperature ramp 10 °C/min. to 130°C, temperature ramp 3°C/min. to 157°C and temperature ramp 20°C/min. to 260°C held for 2.5 min.. The MS source temperature was 230°C and the MS quad temperature 150°C.

The injector temperature was 200°C. The MS monitored in SIM mode the *m/z*s: 39, 42, 68, 72. Dwell time 50msec. The mass spectrometer was operated in electron ionization mode. Furan was detected using single ion monitoring of the fragments *m/z* 68 and *m/z* 39. The internal standard d_4-furan was detected by monitoring the *m/z* 72 and *m/z* 42.

Analytical method
For liquid samples 5 gram of sample is transferred to a headspace vial and spiked with the internal standard d_4-furan. Overall 7 sub-samples are prepared for each type of sample. For biscuits, cookies, French fries and cereals 0.75 gram sample is used which is diluted with 5.5 mL sodium chlorine solution. For samples with low moisture content but high fat content e.g. crisps, only 0.5 gram of sample is used. For other samples 2.5 gram of sample is used, diluted using 2.5 gram of sodium chlorine solution.

For preparation of the standard addition curve for each sample seven vials are fortified with d_4-furan internal standard IS. Three of the vials are sealed directly. The remaining four vials are fortified with furan as following: two vials at ca. ½ of the expected concentration of furan in the sample, one vial at ca. 1 of the expected concentration of furan in the sample, and one vial at ca.

twice of the expected concentration of furan in the sample. An example of the standard addition curve is displayed in the graph below.

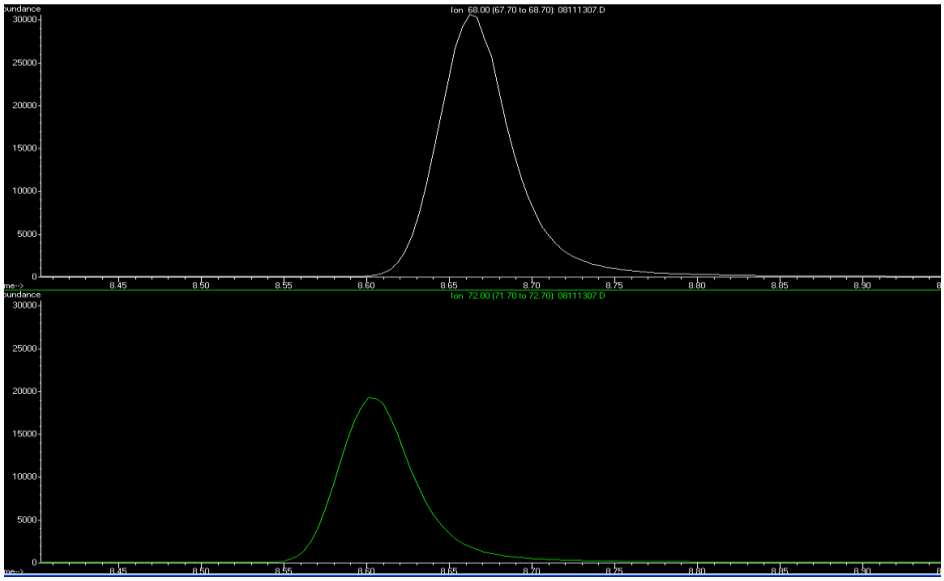


Figure 3. Chromatogram showing IS (*d4*-furan) and furan

The methods internal reproducibility has been tested on three different levels 5 ng/g, 10 ng/g and 100 ng/g. The validation of the method generated a mean RSD for the three levels of 21% for all samples. The repeteatability of the method validated on samples of crisps and porridge oat were 6% and 12%, respectively. The method has a limit of quantification of 2.4 ng/g for all samples except for crisps where the limit of quantification is 2.9 ng/g.

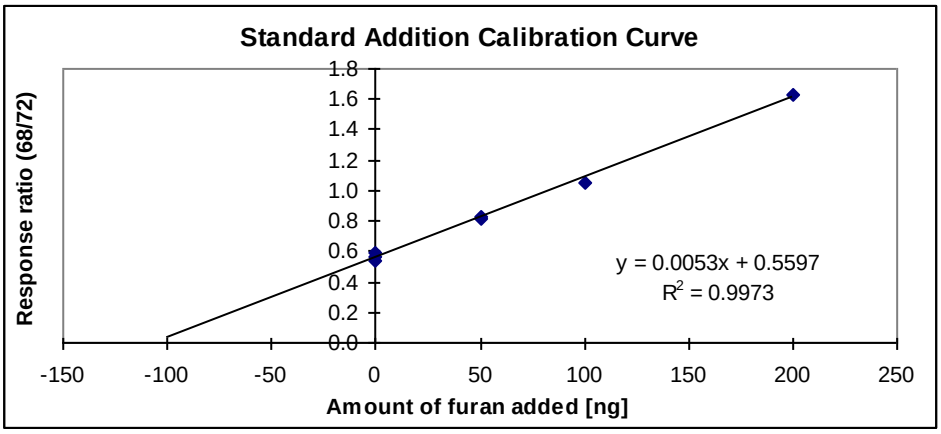


Figure 4. Standard addition curve for a sample of coffee

The National Food Institute is accredited by the Danish accreditation body DANAK according to ISO17025. The laboratory has been accredited since 1995, and has in 2007 a total of 65 accredited analytical methods. The method for furan was accredited in 2008.

Results and discussion

In this section results of the food samples prepared and analysed are presented and discussed. Through the text, where no number of analysis is given the result represents one determination. Results will normally be given in nanogram per gram of the sample (ng/g) or in percent of the initial level of furan.

Home cooked foods

The objective of the project was to evaluate the influence of different cooking procedures used for preparation of various home made food dishes and thereby to locate the preparation methods and the food items most likely to result in high furan levels.

Porridge

Oatmeal porridge has been prepared in a saucepan and in microwave oven, in order to investigate any difference between the two preparation methods.

Table 3. Levels of furan in oatmeal porridge and ingredients [ng/g]

	Preparation method	Furan level [ng/g]
Oatmeal porridge using milk	In a saucepan	<2.4
Oatmeal porridge using water	In a saucepan	<2.4
Oatmeal porridge using water	In microwave oven	<2.4
Ingredients		
Porridge oats		<2.4
Milk		<2.4
Water		<2.4

Porridge is highly consumed by children and fortunately regarding the food safety furan is not found in the porridge independent of the preparation method. The ingredients used to make the porridge were analysed and no furan was found in the ingredients. It can therefore be concluded that furan neither are present in the ingredients nor are formed during the porridge preparation.

Home made soups

Furan has been found in industrially made canned tomato soup and minestrone. Therefore, and because these soups are common soups across Europe, homemade tomato soup and minestrone were made in order to determine the furan levels in home made soups.

Relevant ingredients used to prepare the soups were analysed in order to determine whether the ingredients used to cook the soup contained levels of furan. To make a worst case scenario canned ingredients were used where it was appropriate. Furan was not found in the raw ingredients, including bouillon, rice and bacon nor was furan found in fried bacon. However furan was found in the canned ingredients used for the soups, indicating that furan may be present in the finished soup.

Table 4. Furan level found in the ingredients used for the soups [ng/g]

	Peas	Beans	Tomatoes
Food from the tin	<2.4	6.9	3.0
Water from the tin	6.9	2.5	-

The results for both homemade soups were below 2.4 ng/g furan, as it appears from the table below.

Table 5. Furan level in home made soup [ng/g]

	Finished soup
Tomato soup	<2.4
Minestrone	<2.4

Even though the worst case scenarios were chosen for the preparation of the soups, using canned ingredients, furan was not found in the home made soups.

Fish and meat dishes

Home cooked foods containing fish and meat were prepared on a pan, in a pot and in a wok to include different preparation methods. The prepared dishes included meat balls containing fish or meat prepared on pan, meat sauce prepared in pot and meat and vegetables prepared in wok using soy sauce.

The meat balls and the fish meat balls where fried using either vegetable oil or butter to different browning levels to evaluate the influence of the browning process. The low fat milk (1.5 % fat) used in the preparation of the meat balls was analysed and did not contain furan, however the olive oil did contain furan at a level of 5.1 ng/g oil and may therefore contribute to the content of furan in fried foods. The results from frying of meat balls and fish meat balls are presented in the Table 6.

Table 6. Levels of furan [ng/g] in home fried meat balls and fish balls

	Lightly fried	Medium fried	Heavily fried	Medium fried	Crust from heavily fried	Crust from medium fried	Minced ingredients before frying
Frying agent	Butter	Butter	Butter	Oil	Butter	Oil	
Meat balls	<2.4	<2.4	<2.4	<2.4	2.4	-	6.6
Fish meat balls	<2.4	<2.4	3.1	2.5	2.4	<2.4	<2.4

Furan was found at low level in the heavily fried fish meat balls using butter as frying agent and in medium fried fish meat balls using vegetable oil as frying agent; however furan was not found above the limit of quantification of 2.4 ng/g in the crust of the medium fried meat balls using vegetable oil as frying oil. On the other hand furan was found in the crust of the heavily fried meat balls, but not in the heavily fried meat balls when the whole meat balls were analysed. Surprisingly furan was found in the minced ingredients before frying. However we were not able to find the explanation for the context.

A dish of sweet and sour pork was prepared in a wok in order to determine the influence of using a wok and probably a higher preparation temperature of the home cooked food. Furthermore the dish contained soy sauce and oyster sauce, relevant as soy sauces in previous studies were found to contain furan (Crews & Castle, 2007). However, the home made dishes did not contain furan (< 2.4 ng/g), but some of the analysed ingredients used to prepare the home made dishes, including olive oil, soy sauce, oyster sauce, sambal oelek, did contain levels of furan. Highest levels were found in soy sauce and oyster sauce containing 31.7 ng/g and 38.5 ng/g, respectively and a lower level of furan was found in sambal oelek (2.7 ng/g). Results of the contents of furan are presented in the Table 7.

Table 7. Levels of furan in home made sweet and sour pork including ingredients [ng/g]

Sweet and sour pork (finished)	< 2.4
Sambal oelek	2.7
Soy sauce	31.7
Oyster sauce	38.5
Stock vinegar	< 2.4
Tomato puree	< 2.4
Vegetable oil	5.1
Mushrooms	< 2.4

A traditional meat sauce (Sauce Bolognese) using minced beef was made as it is expected to be consumed in different variants across Europe. The home made dishes did not contain furan above the quantification limit of 2.4 ng/g even though the canned tomatoes used to prepare the dishes did contain a level of 6.0 ng/g furan. Except for the olive oil for frying, the ingredients of the meat sauce analysed, did not contain furan including the beef bouillon and the tomato paste. Results for the furan levels are presented in Table 8.

Table 8. Levels of furan in home made meat sauce including ingredients [ng/g]

Meat sauce (finished)	< 2.4
Vegetable oil	5.1
Beef bouillon	< 2.4
Tomato puree	< 2.4
Tinned tomato	6.0

In conclusion regarding the preparation of home cooked foods only very low levels of furan were observed even though substantial amounts were found in several of the ingredients used for preparation of the home cooked foods with meat or fish content.

Eggs

Omelette was prepared in order to determine the furan level in home made food containing large amounts of eggs.

Table 9. Level of furan in home made food containing large amounts of eggs [ng/g]

Omelette	<2.4

The preparation included intense heating of eggs, however the omelette did not contain furan nor did the raw eggs.

Potatoes

Different samples of potatoes have been prepared. The preparations included deep frying, baking in an oven and preparing on a pan. The prepared dishes included creamed potatoes, marinated potato salad, candied potatoes, French fries, crisps and mashed potatoes.

As a special Danish variant of potatoes candied potatoes was prepared. The potatoes were prepared using a traditional recipe using either fresh potatoes or potatoes from a jar. Furthermore potatoes were prepared using double ration of the caramel for candying the potatoes.

Table 10. Overview of furan levels in home made potato dishes [ng/g]

	Homemade products	Industrially made products prepared in oven	Industrially made products deep-fried
Candied potatoes, fresh potatoes	3.3	-	-
Candied potatoes, jar potatoes	5.7	-	-
Candied potatoes, double caramel	15.5	-	-
Caramel	198	-	-
Marinated potato salad	<2.4	3.9	-
Cream potatoes	2.4	<2.4	-
Mashed potatoes	<2.4	<2.4	-
French fries	-	3 - 15	11 - 21
Crisps	12 - 51	-	

A number of the potato dishes contained measurable amounts of furan and will therefore contribute to the intake of furan through the diet (Table 10).

Industrially made French fries were prepared by deep-frying at different temperatures and frying in an oven at different temperatures. The oil used for frying of the French fries was analysed for furan and had no initial content of furan (<2.4 ng/g). Results of the formation of furan in fried French fries are presented in the Tables 11 and Table 12.

Table 11. Furan formation in fried French fries in triplicates [ng/g]

	160°C for 6 minutes	175°C for 4 minutes	190°C for 3 minutes
1	11.9	12.3	17.0
2	11.1	10.5	17.2
3	11.5	13.3	20.6

The results show no differences between frying the French fries at 160°C for 6 minutes and 175°C for 4 minutes, however higher levels of furan were found in the French fries fried at 190°C for 3 minutes. These French fries did also have a browner colour than the French fries fried at lower temperature.

Table 12. Furan formation in French frites prepared in oven in triplicates [ng/g]

	200°C for 20 minutes	220°C for 20 minutes	240°C for 20 minutes
1	5.5	11.7	8.0
2	7.9	3.9	15.3
3	9.5	2.9	15.3

For the French fries prepared in an oven the lowest results were observed at 200°C and 220°C, and higher results at 240°C. However the results of furan in the French fries as a function of the preparation temperature may not be described by a simple linear relationship. The temperature in the French fries was monitored during the preparation and it was observed that the temperature never rose above 100°C. It is however presumed that the formation of furan primarily take place at the surface where the temperature was above 100°C.

It should be noted that it is difficult to reproduce the furan levels in potato frying experiments, i.e. to get the same results when you repeat a frying experiment. The variations may be even higher for home-preparation of potatoes and may depend on potato varieties, potato quality, length of storage, the quality of the heating equipment etc. Like with formation of acrylamide during frying of potatoes the furan formation may depend on the level of sugars in the potatoes, which increases during storage and when using cold storage (<8°C) (Olsson *et al.* 2004). In addition the formation of furan may depend on the level of ascorbic acid (Vitamin C) in the potatoes, and on the ability of frying oil to contribute to the furan formation at the potato surface.

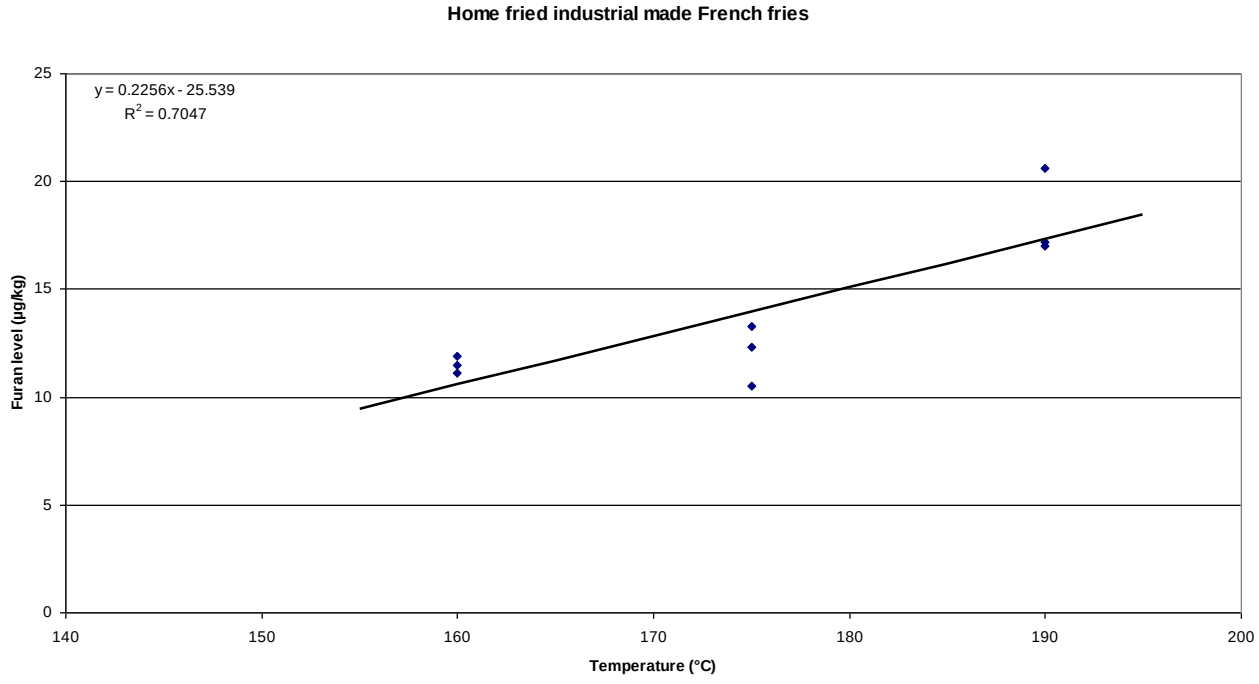


Figure 5. Correlation between temperature and furan content in fried French fries

Preparation of home made crisps

The effect of preparing homemade crisps produced under similar general conditions as in industry was investigated using potato slices (diameter: 40 mm, width: 2.0 mm) of the variety Verdi (72% moisture content) The crisps were prepared using frying in palm oil (Fritex, Århus olie, Denmark) at 150°C for 7 min. or frying at 170°C for 5 min or frying at 190°C for 3.5 min. The different preparation methods all produces crisps with a water content of approximate 2%. The raw potatoes used for preparation of the crisps and the frying oil were tested and was found free from content of furan (below 2.4 ng/g). Results of frying the home cut crisps are presented in table 13.

Table 13. Results for frying of home made crisps

	150°C for 7 minutes	170°C for 5 minutes	190°C for 3½ minutes
A1	14.9	29.6	51.1
B1	-	24.0	36.3
A2	11.9	36.0	49.8
B2	-	22.8	31.3

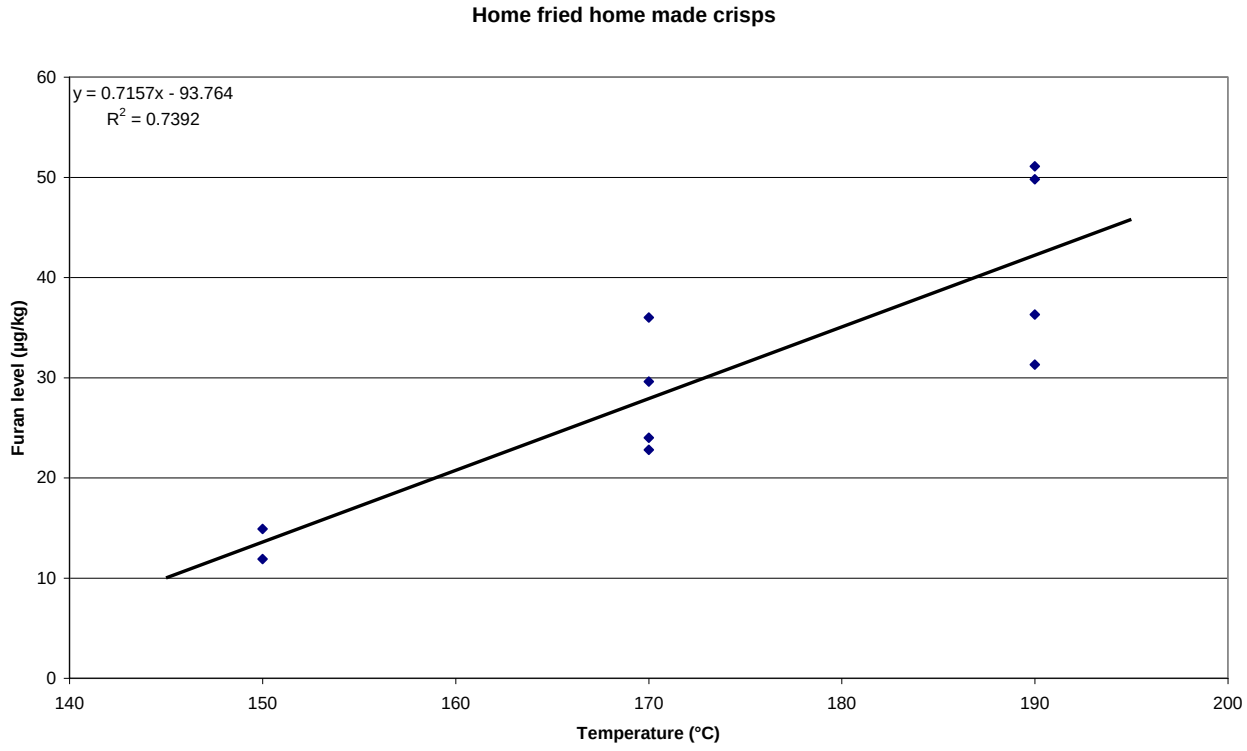
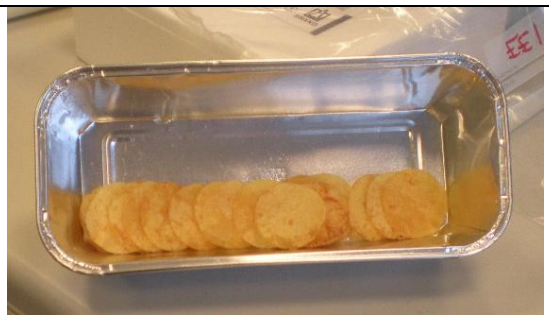


Figure 6. Effect of temperature on furan formation in home made crisps

The result from the frying of the home made crisps seems to reveal a linear correlation between the frying temperature and the furan content in the final product. The home cut, home cooked crisps had a thickness of about 1 mm and the entire crisp was expected to be heated to about the frying temperature resulting in the correlation. This is different from the frying of French fries where only

the surface is expected to reach the temperature of the frying oil whereas the crumb, containing high amounts of water, is expected to only reach about 100°C.

Figure 7. Home cut crisps before frying



Fried home made crisps

Sweets

Home made pancakes, orange cream, fruit compote, apple pie, apple cake, syrup cake and cookies have been prepared.

Pancakes were prepared using different browning levels as well as thicknesses and varying recipes. The results appear from the table below. The temperature in the pancakes was determined and it was observed that the temperature did not increase to above 100°C. Results show that low levels of furan may be observed. The normal pancakes were about 1 mm thick and the thick pancake was about 3 mm thick.

Table 14. Levels of furan in home made pancakes [ng/g]

	Lightly fried	Medium fried	Heavily fried
Normal recipe	<2.4	<2.4	<2.4
Recipe using more plain soda water	-	-	2.6
Thick pancake	-	-	<2.4

Results of furan in the other home made cakes and desserts are presented in Table 15.

Table 15. Levels of furan in home made cakes and desserts [ng/g]

Home made sweets		Ingredients used for home made sweets			
Syrup cake	<2.4	Syrup	18.2	Buttermilk	<2.4
Cookies	<2.4	Chocolate	11.0	Peanuts	2.9
Caramel sauce	<2.4	Cream	<2.4		
Lemon cream	<2.4	Lemon juice	<2.4	Milk	<2.4
Apple pie	4.4	Water	<2.4	Apple	<2.4
Danish apple cake	23.4	Apple sauce	<2.4	Rusks*	11.7
Fruit compote	<2.4	Water	<2.4		

*The prepared rasp from rusks, butter and sugar has a furan content of 133 ng/g. This prepared raps is used for the homemade apple cake.

Cakes and desserts containing high amounts of sugar are more likely to contain measurable amounts of furan. It is nevertheless most pronounced to find furan in the products where high levels of furan are found in the ingredients used to prepare the sweets.

Bread

Home made white bread and tea buns have been baked and samples of the baked bread have been analysed.

Table 16. Furan levels in home made bread [ng/g]

White bread	<2.4		
Tea buns	<2.4	Raisins	83

Furan was not observed in the products, however when analysing the raw raisins used for the tea buns high levels of furan was found constituting an undiscovered food group in relation to intake of furan. As the raisins in tea buns are heated in the oven, an experiment was carried out heating solely the raw raisins in the oven in order to simulate the heating. After heating in the oven, the raisins did not contain any furan. However raisins are often eaten fresh, especially by children, and are therefore a food source of furan.

Toasting of industrially made bread containing ascorbic acid have been analysed in order to determine the influence of home toasting of bread on the levels of furan. Ascorbic acid is an antioxidant and may also be added to the flour in order to achieve satisfactory structure for the bread. In the experiment slices of 13 mm thickness and from a single bread have been used. The bread slices were toasted to increasing browning level (increasing toasting time). The untoasted bread analysed did not contain furan above 2.4 ng/g. Results and pictures of the toasted bread are presented in the table below.

Table 17. Furan level in home toasted bread [ng/g]

						
Ultra light toasted	Very light toasted	Light toasted	Slightly brown	Light brown	Brown	Dark brown
<2.4	<2.4	<2.4	<2.4	<2.4	2.5	17.3

The results show a clear correlation between the degree of browning of the bread slices and the level of furan formed in the bread slices.

The experiment was extended with more extreme browning of the bread. In the second experiment the bread slices were again toasted to different browning levels, however in this experiment until the bread slices were almost black.

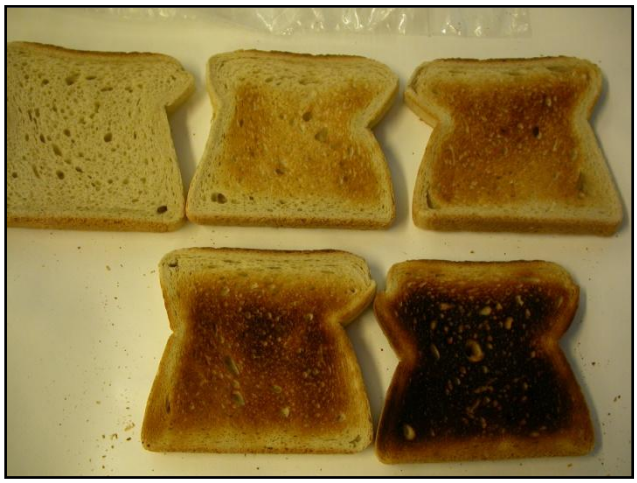


Figure 8. Picture showing the different degree of browning

Table 18. Furan level [ng/g]

Untoasted	Slightly brown	Light brown
<2.4	<2.4	<2.4

Table 19. Furan level [ng/g]

Dark brown	Black
83	179

The dark and black toasted bread had high to very high levels of furan and the degree of browning of the toasted bread has very high influence on the amount of furan in the food item and therefore influence on the amount of furan consumed. The intake by consumers of furan from toasted bread might therefore be reduced by informing about the negative consequences of hard toasting of the bread.

Investigation of the influence of using food additives

The influence of using food additives on the furan level in home cooked food has been investigated by preparing stewed apples with thyme using ascorbic acid and sodium benzoate in the preparation. Sample of stewed apples were prepared either without ascorbic acid and sodium benzoate, by using ascorbic acid and sodium benzoate levels as described in the recipe, by using high levels of ascorbic acid and sodium benzoate and by using only high level of ascorbic acid. Results are displayed in the table below.

Table 20. Furan level [ng/g] in food using food additives

	A	**B**
Apple pure	<2.4	<2.4
Apple pure using normal levels of ascorbic acid and sodium benzoate	<2.4	<2.4
Apple pure using high (4 times) levels of ascorbic acid and sodium benzoate	<2.4	<2.4
Apple pure using high (4 times) levels of ascorbic acid	<2.4	<2.4

The results show that there is no production of furan using the different preparation methods with food additives in apple pure. Limacher et al. (2007) has reported formation of furan in the presents of ascorbic acid, however with highest levels in correlation with roasting in the model system.

Ready-to-eat foods

The objective was to assemble knowledge of the influence of heating and reheating of ready-to-eat foods. Furthermore ready-to-eat products not intended to be heated for example beverages and breakfast cereals were investigated in order be able to make an assessment of the furan level in the ready-to-eat products as a group.

For the dishes that may be reheated, samples were taken before heating, just after preparation and in addition when the food had cooled for one hour after preparation and then was reheated.

The samples have been heated either in a pot or in a microwave oven. The furan loss from the samples show no clear difference, when comparing heating in a pot and heating in a microwave oven.

Table 21. Effect on the furan levels of heating ready-to-eat foods

Sample	Before heating [ng/g]	Furan left after heating [percent]	Furan left after reheating [percent]
Tomato soup	22	44%	24%
Tomato soup	10	67%	45%
Meat sauce	40	40%	-
Mock-turtle	7	51%	45%
Chicken soup	13	8%	-
Minestrone	26	48%	-
Oxtail soup	45	27%	-
Oxtail soup	45	35%	-
Curry soup	47	33%	-
Curry soup	47	21%	-
Minestrone	39	28%	-
Cream potatoes	<2.4	0%	-
Mashed potatoes	2.5	0%	-
Infants vegetable meal	45	51%	-
Baked beans	102	41%	-
Sweet & sour vegetable sauce	13	56%	-
Patty shell	-	(18.2 ng/g)	-
Noodles	-	0%	-
Honeycomb	-	0%	-
Naan bread	-	0%	-
Naan bread with butter	-	0%	-

For most of the ready-to-eat samples examined heating reduced the furan content to roughly half the initial level and reheating reduced the furan level further. Therefore with a high initial level of furan in the ready-to-eat product levels of furan should be expected in the foods consumed.

Beverages
Hot and cold beverages have been investigated as the beverages either may be consumed directly or be a part of the ingredients in home cooked foods.

The coffee was brewed as described on the label or for brewed coffee using milled coffee beans extracts were made using 40 gram of coffee beans per litre boiled water.

Table 22. Levels of furan in ready-to-eat products - coffee

Brewed from	Furan level in the brewed coffee [ng/g]	Furan level in the powder [ng/g]	Furan transferred from the powder to the brewed coffee
Milled coffee beans	21.3	-	-
Milled coffee beans	14.7	-	-
Milled coffee beans	4.3	-	-
Milled coffee beans	56.6 - 56.7	1966	71%
Milled coffee beans	52.5 - 76.1	1681	78% - 113%
Milled coffee beans	47.7 - 55.2	1892	63% - 73%
Milled coffee beans	-	1222	-
Milled coffee beans	-	1863	-
Instant coffee	6.6	1330	50%
Instant coffee	<2.4	122	-
Instant coffee	<2.4	421	-
Instant coffee	4.3	625	43%
Instant coffee	<2.4	286	-
Instant coffee	<2.4	388	-
Instant coffee	-	192	-
Instant coffee	-	127	-
Instant coffee	-	264	-

The milled coffee beans were analysed and calculations show that 43-100 % of the furan in the coffee beans were extracted into the brewed coffee i.e. a large part of the initial furan found in the milled coffee powder of the instant coffee powder will be transferred into the brewed coffee and therefore consumed. In spite of this it should be noted that usually lower levels of furan are found in the instant coffees compared to the ground coffees.

Levels of furan in other beverages were determined and an overview of the determined results appears from Table 23.

Table 23. Levels of furan in beverages [ng/g]

Beverage	Additional description	No. of analyses	Preparation	Furan [ng/g]
Water	-	2	Cold	<2.4
Orange juice	-	3	Cold	<2.4
Tomato juice	-	1	Cold	<2.4
Pear-apple juice	-	1	Cold	<2.4
Vegetable drink	Tomato juice with carrots	2	Cold	<2.4
Buttermilk	Max. 1 % fat	1	Cold	<2.4
Milk, minimal fat	0.5 % fat	1	Cold	<2.4
Milk, semi fat	1.5 % fat	2	Cold	<2.4
Milk	3.5 % fat	2	Cold	<2.4
Milk, whole	3.7-4.2 % fat	1	Cold	<2.4
Cream	9 % fat	1	Cold	<2.4
Cream, double	38 % fat	1	Cold	<2.4
Ice tea	-	1	Cold	<2.4
Soft drinks	-	2	Cold	<2.4
Syrup	Concentrate	9	Cold	<2.4
Beer	-	5	Cold	<2.4 - 2.9
Cacao	Prepared from powder	1	Hot	<2.4
Tea	-	1	Hot	<2.4
Coffee	Milled coffee beans used	8	Hot	6.6 – 76.1
Coffee	Instant coffee	10	Hot	<2.4 – 4.3

For all the samples of beverages except for one sample of beer furan was only found in coffee. Other studies have shown furan in beverages as juices and beers (Crews & Castle 2007; Morehouse *et al.* 2007; Zoller *et al.* 2007), however only at low levels.

Ready-to-eat products including sweets, fruit, biscuits, crisps and infants foods

A number of ready-to-eat sweets has been analysed to be used for an assessment of the furan intake from sweets.

Table 24. Furan contents in ready-to-eat sweets, nuts and fruit [ng/g]

Milk chocolate	3.8
Dark chocolate	11.0
Hazelnut cream	<2.4
Peanuts	2.9
Cookie	8.8
Hazelnut	<2.4
Peanut cookies	5.3
Chocolate cookies	<2.4
Macaroon	3.6
Strawberry jam	<2.4
Orange marmalade	<2.4
Apple pure (from glass)	<2.4
Dates sun dried	2.4
Banana crisps	10.8
Fruit cocktail tinned	<2.4
Apple	<2.4
Fruit filling	2.4
Stewed plums	<2.4
Plums dried	9.6
Raisins	2.5
Raisins	83
Cranberry dried	<2.4
Figs dried	<2.4
Pineapple dried	6.3
Pineapple slices	<2.4
Pineapple pieces	<2.4
Apricots sun dried	<2.4
Asparagus tinned	3.0
Asparagus tinned	2.5
Cucumber in glass	3.8
Peas, carrots, asparagus	2.8
Peas	3.4
Maize tinned	6.2
Maize tinned	<2.4
Zucchini tinned	4.2
Kidney beans	2.6
Tomato tinned	12.0
Tomato tinned	3.0
Tomato tinned	6.0
Tomato tinned	5.3
Tomato tinned	8.2
Pomodori tinned	<2.4
Tomato puree tinned	<2.4
Tomatoes sun dried (from glass)	2.5
Tomatoes sun dried	2.5

Furan was found in several samples of dried fruits and vegetables, e.g. in raisins, sundried dates, dried plums, dried pineapple, dried banana, sundried tomatoes. However, furan was not present in all dried fruits and vegetables (e.g. not in the samples of dried figs, apricots, cranberry and some of the dried pineapples). Dried fruits might be consumed by children and findings of furan in these products may cause food safety concern. The majority of the tinned tomato products contained furan. The cause of the occurrence of furan in sundried fruits and vegetables is not clear. One hypothesis may be that the furan is formed in a Maillard reaction during the sun drying.

Table 25. Furan contents in ready-to-eat crisps [ng/g]

Corn crisps	8.1
Potato crisps	<2.4
Bacon snacks	26.1
Extruded snacks	<2.4
Bacon snacks	<2.4
Tortilla chips	15.4
Corn crisps	26.2
Extruded snacks	52.3
Popcorn	90.6

Popcorn has a very high level of furan, but furan is also found in considerable amounts in the other crisps products, some of them eaten in large quantities by children. Some of the products were, nevertheless free from content of furan.

Table 26. Furan contents in ready-to-eat breakfast cereals [ng/g]

Honey coated	61.1
Whole grains flour	6.1
Corn flakes	86.7
Honey coated	387
Oatmeal	<2.4
Rice based	<2.4
Whole grains flour	43.1
Müsli	5.9
Oats flakes	3.0
Junket rasp	<2.4
Whole grains flakes	38.2

Furan was found in breakfast cereals, products highly consumed by children. Surprising high levels of furan was found in honey coated products. As these foods contain high levels of carbohydrates it is most likely that the furan formation in particular is related to the precursor's carbohydrate or sugars.

Table 27. Furan content in ready-to-eat dry bread products [ng/g]

Crispbread	72.9
Toasted bread	9.0
Crust	4.9
Crust	18.1
Rice cakes	74.0

High amounts of furan are found in ready-to-eat dry bread products, especially the crispbread. It is however noticeable that all the samples of dried bread had contents of furan. The furan level might be associated with the use of ascorbic acid in the flour used for the bread combined with a baking process leaving low levels of water in the final products.

Table 28. Furan contents in ready-to-eat foods intend for infants [ng/g]

Infants food with peas, banana and rice in glass	<2.4
Infants food with apple in glass	<2.4
Infants food with apple, banana and peach	<2.4
Infants food with carrots and maize	44
Infants food with tomato in glass	45

Relatively high concentrations of furan are found in two of the food samples especially intended for children. Within these few samples analysed infants foods containing fruits did not contain furan whereas infant foods containing vegetable did.

Table 29. Furan contents in canned and jarred ready-to-eat products and the water/oil from the tin or jar [ng/g]

Food	Food item	Water or oil from the tin or jar
Tomatoes sun dried in oil	2.5	5.3
Pomodori in oil	<2.4	28.8
Zucchini in oil	4.2	22.5
Peas in water	3.4	5.6
Peas in water	<2.4	6.9
Beans in water	6.9	2.5

When looking at tinned or jarred ready-to-eat food items which are stored in water or oil, there is a large difference between the furan levels found in the food item itself and the water or oil from the tin. The highest levels of furan were in all cases found in the water or oil from the tin or jar and not in the food item itself, with the exception of the beans. It is therefore important for the furan intake whether the water or oil is eaten, either directly or used in a home cooked meal.

Changes in furan concentrations due to heating

The objective was to investigate different heating procedures including different heating temperatures, heating techniques and reheating of food in order to determine the stability of furan under these conditions.

Table 30. Changes in furan concentrations due to heating

Food item	Heating technique	Furan level before heating [ng/g]	Furan left after heating [Percent]	Max. Temperature [°C]
Tomato soup	Pot	21.7	44%	89
Tomato soup	Pot	9.6	67%	90
Tomato soup	Pot	-	0%	81
Minestrone	Pot	-	0%	100
Meat sauce	Pot	40.4	40%	-
Mock-turtle	Pot	7.0	51%	85
Chicken soup	Pot	12.7	8%	98
Minestrone	Pot	25.9	48%	100
Oxtail soup	Pot	44.8	35%	97
Curry soup	Pot	46.5	21%	98
Minestrone	Pot	38.8	28%	100
Baby food	Pot	45.2	51%	90
Baked beans	Pot	106	41%	90
Vegetable sauce	Pot	13.4	56%	95
Lobster Bisque	Pot	27.0	42%	88
Lobster Bisque	Pot	27.0	59%	82
Goulash	Pot	85	20%	88
Mashed potatoes	Oven	5.4	0%	95
Cream Potatoes	Oven	<2.4	0%	102
Curry soup	Microwave oven	46.5	33%	82
Oxtail soup	Microwave oven	44.8	27%	92
Lobster Bisque	Microwave oven	27.0	59%	78
Lobster Bisque	Microwave oven	27.0	88%	68
Minestrone	Directly in the tin	25.9	96%	72
Chicken soup	Directly in the tin	12.7	27%	87

The changes in the furan concentrations seem to be more influenced by the maximum temperature achieved by the heating process, than by the heating process itself. However it seems to be more likely that heating in microwave oven may give more different temperatures. Therefore, if the food is heated to a lower temperature in a microwave oven, higher proportions of the initial amount of furan will remain in the food item.

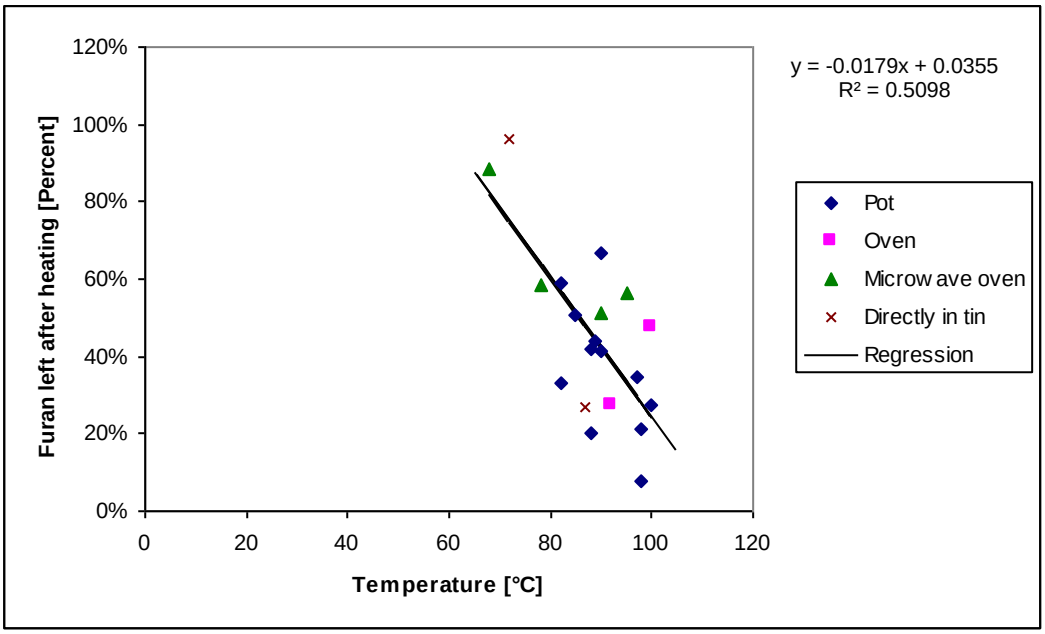


Figure 9. Correlation between maximum heating temperature and furan left in the food item

Figure 9 displays the correlation between the maximum temperatures measured around the cooked foods where finished and the furan left in the foods, separated into the different preparation methods, cooked in a pot, cooked in oven and cooked in microwave oven. A correlation between the maximum temperature and the furan is observed. Conversely, no clear difference between the cooking method used and the furan level is observed.

Table 31. Changes in the furan concentrations due to heating and reheating

Sample	Before heating [ng/g]	Furan in heated food [ng/g]	Temperature in heating [°C]	Furan in heated product [ng/g]	Temperature in reheated food [°C]
Tomato soup	22	10	89	5	64
Tomato soup	10	6	90	4	77
Mock-turtle	7	4	85	3	90
Tomato soup	-	<2.4	81	<2.4	100
Minestrone	-	<2.4	100	<2.4	99

Furan evaporation from foods over time

The objective was to evaluate the changes in the furan level over time as furan is highly volatile and the concentrations might therefore change if the heated food product is left to stand after preparation. Samples have been heated and afterwards left to cool for 60 minutes with sampling every 10 minutes. The results show that the furan levels are almost constant after heating and the furan losses are not considerably over time when the meals not are heated (are left to stand).

Almost all results for the home made soups were below 2.4 ng/g furan i.e. there was no clear development in the furan concentration over time in these experiments, however low levels of furan were found in some of the samples indicating that furan are present in the soup.

Table 32. Development in the furan concentrations over time in home made soups [ng/g]

	Finished soup	10 min.	20 min.	30 min.	40 min.	50 min.	60 min.
Tomato soup	<2.4	<2.4	<2.4	2.4	<2.4	2.8	2.4
Minestrone	<2.4	<2.4	3.8	<2.4	<2.4	<2.4	3.0

For comparison industrially made soups and foods with known content of furan were examined in order to determine the development in the furan levels compared to the initial level.

Table 33. Development in the furan concentrations over time in industrial made products [ng/g]

	Before heating	Heated	10 min.	20 min.	30 min.	40 min.	50 min.	60 min.
Tomato soup	22	10	8	8	8	10	11	10
Tomato soup	10	6	7	6	8	6	6	7
Mock-turtle	7	4	8	7	8	7	8	6

When an initial level of furan is present in the food item heated, changes in furan levels appear when the food item is heated. Heating the food item almost reduced the furan level in the food by 50%, however the furan level in the foods do not change when left for cool for one hour, and furan therefore seems to be stable in the food when it is not heated.

Goulash was heated in a pot, and the goulash was kept heated for 26 minutes after the dish was prepared. Samples have been taken when the goulash was heated during preparation, again when the goulash was heated for 10 minutes after preparation, 20 minutes after preparation and finally when the meal was heated for 26 minutes after preparation, where the goulash began to develop an unpleasant odour and the meal started to be burned at the bottom of the pot. Results are presented in Table 34 below.

Table 34. Development in the furan concentration and temperature over time for goulash

Goulash	Before heating	Heated	Heated for 10 minutes more	Heated for 20 minutes more	Heated for 26 minutes more
Temperature [°C]	22	88	97	89	84
Furan level [ng/g]	85	17	17	9	8

Results again confirm the previous findings that furan is stable in food even when heated. The large proportion of furan was liberated during the first heating of the foods and further heating of the goulash only results in minor changes in the concentrations.

An experiment to analyse the stability of furan in toasted bread was performed, as the hypothesis was that furan might evaporate after toasting of the bread.

Table 35. The stability of furan in toasted bread [ng/g]

	Not toasted	Dark brown	10 min. after toasting	20 min. after toasting	30 min. after toasting
A	<2.4	54	85	171	309
B	<2.4	85	-	-	312

The very surprising results revealed an increasing level of furan in the toasted bread that was left at room temperature to cool before sampling. An increasing level of furan was observed in the toasted bread which has been left to cool after preparation, which might suggest further Maillard reactions of more unstable intermediate compounds formed during toasting of the bread. Further experiment should look into this increase in the furan level in toasted bread, especially whether there is a correlation to the ascorbic acid added to the flour used for the bread.

Home made cream potatoes prepared in an oven were sampled immediately after the meal was prepared and again after one hour of cooling.

Table 36. Results for the stability of furan in home made cream potatoes prepared in oven

Cream potatoes	Finished cream potatoes	60 min. later
Temperature [°C]	96	60
Furan level [ng/g]	2.4	4.0

In the cream potatoes furan seems to be quite stable as the level of furan is actually slightly higher after 60 minutes cooling than immediately after the meal was prepared.

Dietary intake of furan for adults and children

On basis of analysed data, a few supplementary furan data from the literature (Crews & Castle 2007) and intake of foods and beverages from the Danish National Survey of Dietary Habits and Physical Activity 2000-2004, the exposure of furan has been calculated. The dietary survey is a cross sectional survey comprising a random sample of 4120 individuals aged 4–75 years from the central population register. Dietary intake was obtained using a 7 d pre-coded food diary with response categories for the most commonly eaten foods and dishes in the Danish diet supplemented with open-ended alternatives. The amounts of food consumed were given in household measures (cups, spoons, slices, etc.) or estimated from photos of different portion sizes showing four to six different portions. Trained interviewers from the Danish National Institute of Social Research gave instructions on how to complete the food diary and how to estimate portion sizes. The interviewers also conducted in-person interviews in order to obtain information on variables such as social background, leisure-time physical activity, height, body weight and intentions to eat healthily. The mean food intakes were calculated for each individual using the General Intake Estimation System (GIES) version 0.995a (Danish Institute for Food and Veterinary Research, Søborg, Denmark).

In the present analysis data from children 4-6 years (n=335) and adults 15-75 years (n=4692) has been used. Calculations of the furan exposures show a median intake of 1.1 µg/day for children (mean 1.5 µg/day) and a median intake of 33.5 µg/day for adults (mean 27 µg/day). For adults the main contributor (95%) to the exposure of furan is coffee. Adults in Denmark have like other parts of Northern Europe an average daily intake of more than 0.6 L of coffee (The coffee is mostly made of 40 g medium roasted ground coffee per litre water), while the intake in the Southern part of Europe, e.g. Italy is much lower (Johansson et al, 1998; Fagt et al, 2008; Ferranoni et al, 2004). The figure below illustrates the food contributions to the intake of furan for adults. The mean coffee exposure is 26 µg/day based on a mean coffee intake of 0.67 L brewed coffee with a furan concentration of 38 ng/g. The 95 percentile drinks 1.77 L coffee per day and their exposure is 67µg/day based on the mean furan level of coffee of 38 ng/g. When based on a high level of furan in coffee of 72 ng/g, the 95 percentile exposure figure is 127 µg/day (Table 35). EFSA (2009) estimated the dietary intake of furan from coffee to contribute between 43-79 % of the total mean dietary exposure. Looking at e.g. the German figures the mean furan exposure from coffee contributed 75% of the total mean exposure of 57µg/day (for a 60 kg person) = 43 µg/day, somewhat higher than the finding from this study of 26 ng/day from coffee. The French population was exposed to 26 µg furan/day from coffee (75% of total exposure of 34 µg/day for a 60 kg person). For a Dane weighing 60 kg the mean exposure of 27 µg/day correspond to 0.45 µg/kg body weight/day.

The consumption data and furan contents in foods most relevant for furan exposure are presented in Table 35 together with the mean exposures, the 95 percentile exposures and the 95 percentile exposures using high occurrence figures.

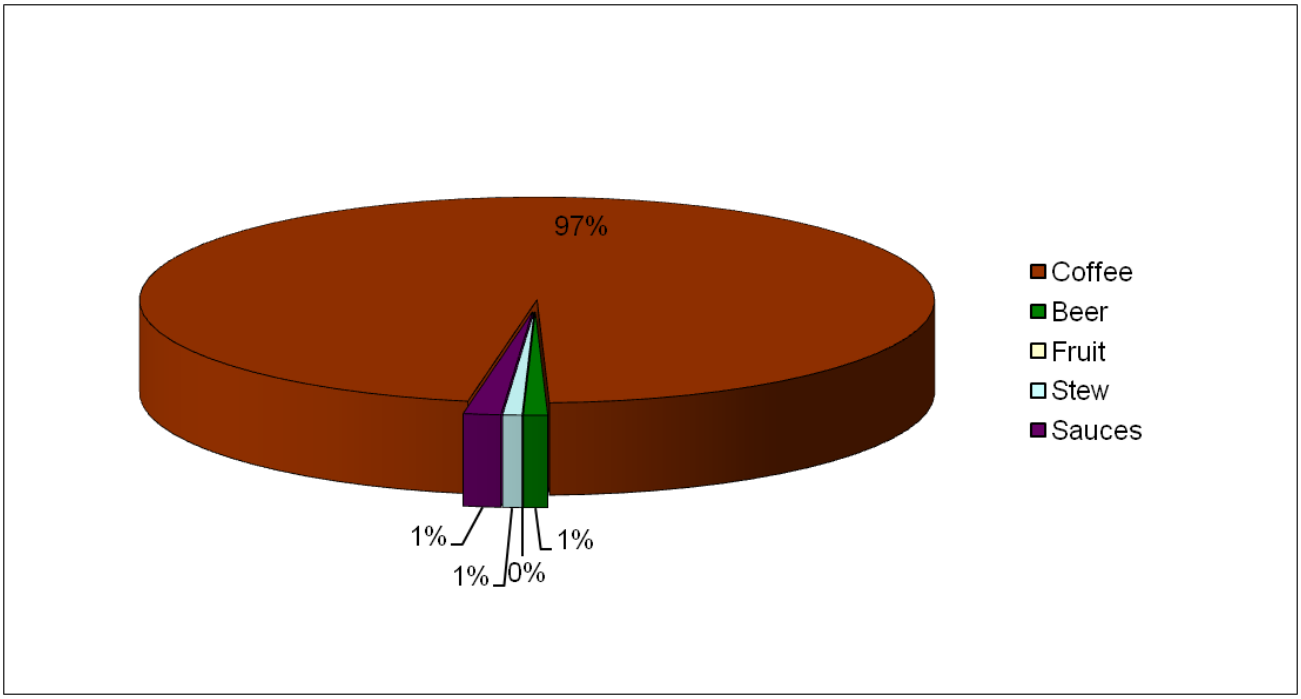


Figure 10.Foods contributing to the median intake of furan for adults of 34 µg/day

As children do not have a high intake of coffee, the foods contributing to the intake of are from other sources. Figure 11 illustrates that the main food group contributing to furan is the breakfast cereal as high levels of furan was found in the breakfast cereals combined with children's high consumption.

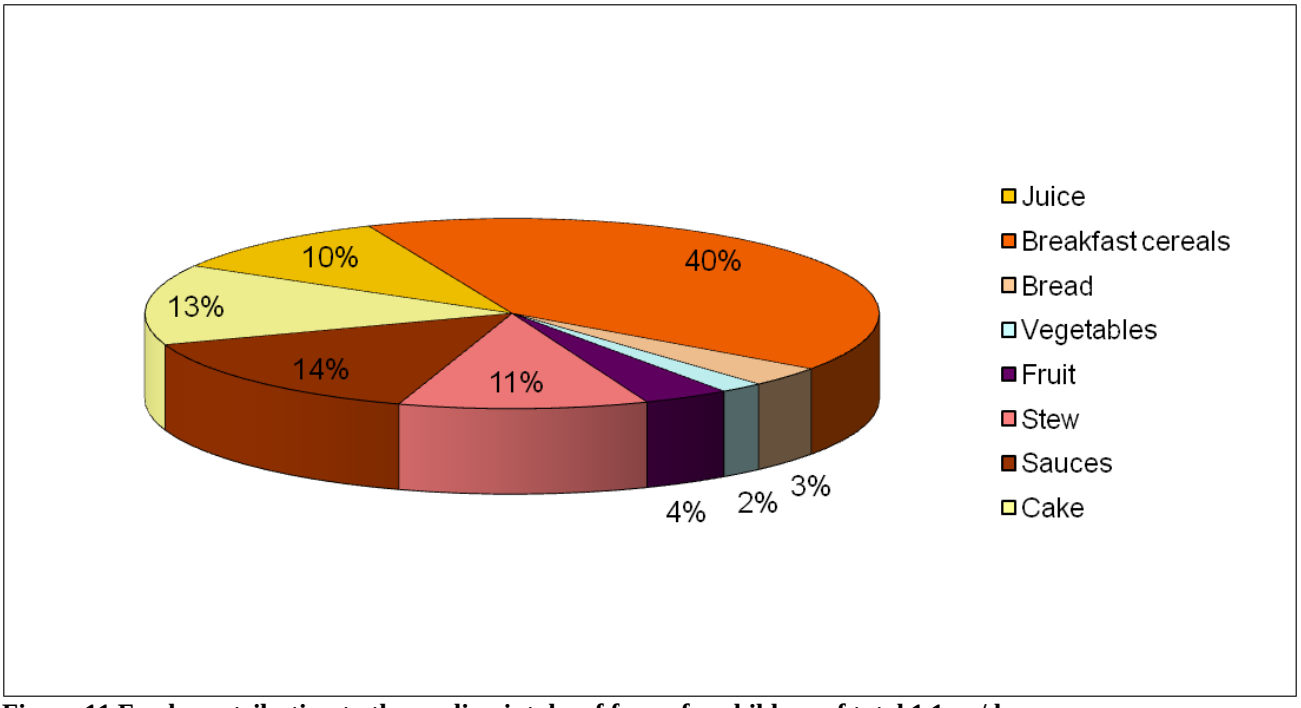


Figure 11.Foods contributing to the median intake of furan for children of total 1.1 µg/day

An overall conclusion is that especially dry food products contributed to the intake of furan, though juices and sauces also contributed.

As the Food consumption data do not include information on toasting of bread, this is not included in the exposure estimates. However, the mean daily consumption of bread is 105 g for children 4-6 years and 128 g for adults and the 95 percentiles 216 g and 287 g, respectively. If children and adults eat 60 g toasted bread /day (2-3 slices) containing 17 ng furan/g, the daily exposure increases with 1µg, which makes no difference for adults drinking coffee, but double the furan levels in children aged 4-6 years.
When comparing the intake estimates from this study, with the furan estimates calculated by Heppner and Schlatter (2007), the findings regarding the meals studied are comparable. However, the present study additionally includes breakfast cereals, an important contributor to the children's exposure to furan.

Table 37. Food consumption for children aged 4-6 years and adults, furan concentration in the foods, mean and 95 percentile exposure estimates for children aged 4-6 years and adults.

	Consumption children	Consumption adults	Mean furan conc.	High furan conc.	Mean exposure children	High exposure children (95 perc.)	High exposure children (95 prec., high conc.)	Mean exposure adults	High exposure adult (95 perc.)	High exposure adult (95 perc., high conc.)
	g/day	g/day	ng/g	ng/g	ng/day	ng/day	ng/day	ng/day	ng/day	ng/day
brewed coffee	0	673	38	72	0	0	0	25747	67757	127189
juice etc.	301	253	1	2	275	1005	1608	211	914	1686
beer	0	184	2	2	0	0	0	269	1131	1853
cornflakes	4	3	34	94	140	603	1684	86	603	1684
breakfast cereals	4	1	109	370	448	2324	7882	73	531	1799
oatmeal	7	5	1	3	6	32	99	4	31	95
crispsbread	1	1	34	34	36	176	176	39	235	235
biscuits	2	1	8	9	13	84	95	7	42	47
rice cakes	0.1	0.1	74	74	6	6	6	5	5	5
fruit filling	2	0	4	4	7	36	36	2	9	9
marmalade	2	5	1	3	3	14	29	7	27	53
patty shells	0	1	18	18	0	0	0	18	18	18
peas & beans	3	4	5	5	14	79	79	22	112	112
corn	2	2	7	7	13	78	78	11	66	66
asparagus	0.1	1	3	4	0	0	0	2	12	16
cucumber jarred	1	4	4	4	4	28	28	16	28	98
raisins	2	2	22	64	54	249	729	43	261	766
pineapple	1	1	5	5	3	25	25	3	3	3
coconut milk	0.1	0.1	3	3	0.3	0.3	0.3	0.1	0.1	0.1
meatballs	5	6	0	1	0	0	18	0	0	23
fish meatballs	3	1	2	4	5	37	92	2	20	50
roasted potatoes	15	20	10	21	147	459	936	207	716	1460
mashed potato	5	7	2	5	9	45	123	13	77	208
sauce	2	4	92	272	209	1183	3498	405	1971	5829
cake	11	15	1	1	10	32	32	13	51	51
pancakes	6	4	1	3	9	51	93	6	41	74
cookies	7	6	2	4	12	47	110	10	47	110
chocolate	4	8	6	10	24	86	136	48	21	319
crisps	2	2	21	51	50	228	547	48	273	657
popcorn	1	0	93	137	91	397	586	42	265	390
peanuts	1	1	2	2	1	9	9	2	9	9
nuts etc.	0.4	1	1	1	0	2	3	0	2	4
		total exposure µg/day:			1.6	7	19	27	75	145

Substituted furans

Selected samples have been screened for substituted furans in order to determine the presence of these compounds in the food items. The screening includes 2-methylfuran, 2-ethylfuran, 2-pentylfuran, 2,5-dimethylfuran, 2-butylfuran, 2,3-benzofuran. Two examples of the results found in crispbread and mock-turtle are given below.

Table 38. Examples of results found when screening for substituted furans [ng/g]

	Crispbread	Mock-turtle
Furan	73	7
2-methylfuran	39	4
2-ethylfuran	12	36
2,5-dimethylfuran	<LOQ	<LOQ
2-butylfuran	<LOQ	<LOQ
2,3-benzofuran	<LOQ	<LOQ
2-pentylfuran	68	160

The screening for substituted furan compounds in food items clearly indicates a potentially potent food safety issue concerning toxicological questionable compounds in foods. Analogue to the findings by Limacher *et al.* (2007) the formation of methylfuran might be related to the heating of ascorbic acid.

Conclusions and recommendations

A wide range of homemade dishes were examined for the formation of furan during the preparation of the meals and using different cooking methods.

For the home cooked foods, it can be concluded that foods rich in carbohydrates are most likely to form furan, probably due to a Maillard browning reaction of the food. High levels were found in toasted bread and the content was correlated to the browning level, therefore not to toast the bread to a dark brown colour might reduce the intake of furan, as it is possible to toast the bread without or with negligible formation of furan. Even the worst case scenarios using ingredients containing furan for the home cooked foods did not lead to evaluated levels of furan during cooking.

For ready-to-eat foods with initial occurrences of furan, cooking will reduce the level of furan in the food to about half the initial concentration. Nevertheless, furan is stable in hot food items and the loss of furan present in the food before heating compared to the content after boiling the food is negligible. The furan level remained stable for one hour after heating and it can therefore be concluded that furan is stable in the food items. It was not until the food was reheated that the level of furan decreased.

A number of dried fruits were analysed, revealing large differences between the individual samples. Furthermore samples of breakfast cereals have been investigated and very high levels of furan in several of the products were found.

An estimate for the intake for adults revealed that 95% of the furan intake was related to the intake from coffee. This estimate was however based on the Danish consumption data and as Danes, like other adults from Northern Europe, have an average consumption of more than 0.6 L of coffee per day, the contribution to the total intake might be high. For children with a high consumption of breakfast cereals (the 95 percentile) and a mean consumption of other foods the furan exposure from breakfast cereals account for about 2/3 of the total exposure.

References

Anon (1972) *Ingeborg Suhr Mad.* Suhr´s school of home economics (Eds). Gjellerup, Copenhagen, 1972.

Crews, C. & Castle, L. (2007) *A review of the occurrence, formation and analysis of furan in heat-processed foods.* Trends in Food Science & Technology 18: 365-372.

Crews, C., Hasnip, S., Roberts, D.P.T & Castle, L. (2007) *Factors affecting the analysis of furan in heated foods*. Food Additives and Contaminants, 24 (S1): 108-113.

Dansukker (2009). *Sommer Hjemmelavet er nemt… supernemt*. http://www.dansukker.com/Admin/Public/Cart.aspx?ProductID=16510&BackURL=%2fDefault.aspx%3fID%3d202%26shopping

Debacker N, Temme L, Cox B, Huybrechts I, Van Oyen H (2007). The Belgian Food Consumption Survey 2004.

EFSA (2005). Report of the CONTAM Panel on provisional findings on furan in food Question number: EFSA-Q-2004-109. Version from 7 November 2005. Found on: http://www.efsa.europa.eu/cs/BlobServer/Scientific_Document/contam_furan_report7-11-051.pdf

EFSA (2009). Results on the monitoring of furan levels in food. Question number: EFSA-Q-2009-00607. Issued on 11. June 2009.

Elmadfa I, Weichselbaum E (2005). European nutrition and health report 2004. S. Karger AG.

Fagt S, Biltoft-Jensen, Matthiessen J, Groth MV, Christensen T, Trolle E (2008). *Danskernes kostvaner 1995-2006.* DTU Fødevareinstituttet.

FDA (2004) Exploratory data on furan in food. Data through May 27, 2004. http://cfan.fda.gov/~dms/furandat.html

FDA (2007) Exploratory Data on Furan in Food available at: http://www.fda.gov/Food/FoodSafety/FoodContaminantsAdulteration/ChemicalContaminants/Furan/ucm078439.htm

Fogt KH, Kastberg M, Haveman L. (2007). *God mad - let at lave.* Thomsen HF (ed), Aschehoug, Copenhagen.

Hasnip, S., Crews, C. & Castle, L. (2006). *Some factors affecting the formation of furan in heated foods.* Food Additives and Contaminants, 23 (3): 219-227.

Heppner, C.W. & Schlatter, J.R. (2007). *Data requirements for risk assessment of furan in food.* Food Additives and Contaminants, 24 (S1): 114-121.

Johansson L, Solvoll K, Bjørneboe GEA, Drevon CA (1998). *Under- and overreporting of energy intake related to weight status and life style in a nationwide sample*. Am. Clin. Nutr. 68: 266-274

Limacher, a., Kerler, J., Conde-Petit, B & Blank, I. (2007). *Formation of furan and methylfuran from ascorbic acid in model systems and food.* Food Additives and Contaminants, 24 (S1): 122-135.

Maga, J.A. (1979). *Furan in foods*. Critical reviews in food science and nutrition, 11: 355-400.

Morehouse KM, Nyman PJ, McNeal TP, DiNovi MJ, Perfetti GA (2007). Food Additives and Contaminants. A 25: 259-264

Männistö S, Ovaskainen NL, Valsta L (2003). The National Findiet 2002 study. National Public Health Institute, Helsinki.

Olsson, K., Svensson, R. & Roslund, C. A. (2004). Tuber components affecting acrylamide formation and colour in fried potato: Variation by variety, year, storage temperature and storage time. *Journal of the Science of Food and Agriculture*, 84(5): 447-458.

Perez L.C. & Yaylayan V.A. (2004): *Origin and mechanistic pathways of formation of the parent furan – A food toxicant.* Journal of Agricultural and Food Chemistry, 52: 6830–6836.

Roberts, D. Crews, C., Grundy, H., Mills, C. & Matthews, W. (2008). *Effect of consumer cooking on furan in convenience foods*. Food Additives and Contaminants, 25 (1): 25-31.

Siesbye B & Kirkegaard E. (1989) *Ingeborg Suhr Mad*. Suhr´s school of home economics (Eds). Gjellerup and Gad, Copenhagen.

Thomsen HF. (1985) *Jul fra Brugsen*. FDB, Copenhagen.

Vranová, J. & Ciesarová, Z. (2009) *Furan in food –a Review*. Czech journal of Food Science, 27 (1): 1-10.

Wenzl, T., Lachenmeier, D.W & Gökmen, V. (2007). Analysis of vheat.induced contaminants (acrylamide, chloropropanols and furan) in carbohydrate-rich food. Anal. Bioanal. Chem. 389: 119-137.

Ygil KH. (2008) Personal communication, Department of Nutrition.

Zoller, Sager & Reinhard (2007). *Furan in food:* Headspace method and product survey. Food additives and Contaminants, suppl. 1, 24: 91-107

Recipes

Oatmeal Porridge (source: Good food - easy to do) 1 litre cold water or milk 125 grams (about 4 dl) rolled oats ca. ½ tsp. salt *Pour the liquid and oatmeal into a saucepan. Bring to a boil - stir regularly across the bottom. Reduce heat. Boil porridge approx. 1 min. stirring constantly. Turn off the heat. Add salt to taste.*	
Oatmeal porridge in microwave (1 person) (source: Good food - easy to do) 30 grams rolled oats (about 1 dl) 2 dl water or milk salt *Combine oatmeal and water / milk in a bowl. Microwave approx. 1 ½ minutes. at 800 W. Add salt*	
Tomato soup (source: Good food - easy to do) 2 cans coarsely chopped tomatoes ½ kg onion ca. 1 litre bouillon or broth 1 bundle of herbs 1 bay leaf 1 whole clove 1 leaf thyme 2 cloves garlic 8 whole peppercorns 1 tsp. grated nutmeg a little salt *Peal onions and cut them into quarters. Combine onions and chopped tomatoes in a saucepan and then add broth. Add bundle of herbs and the tea filter bag with spices. Boil soup, 20-30 minutes. Add a little water if necessary. Remove bundle of herbs and filter bag. Blend the soup. Heat the soup thoroughly and add salt and other spices (optional).*	
Minestrone (source: Good food - easy to do) 75-100 g bacon 2 onions 2 cloves garlic 1 carrot (100 grams), (may be canned) ¼ small white cabbage (200 grams) 1 leek (150 g) 4-5 stalks celery or ¼ celeriac (150 g) 1 can coarsely chopped tomatoes 1 ½ to 2 litres of bouillon or broth 150g fresh, frozen or canned green beans 125 grams of peas, (may be canned) 2 twigs parsley 2 twigs basil 1 leaf thyme ca. 50 g small pasta shapes or ¾ dl rice salt and freshly ground pepper *Cut the bacon into small cubes. Rinse vegetables. Chop the onion and garlic. Cut the carrot and leek into slices, celery into cubes and cut the cabbage finely. Cut green beans into smaller pieces. Fry bacon in a large thick bottomed saucepan, until most of the fat has melted. Add vegetables (except green beans and peas) and fry shortly.Pour the broth over the*	

fried vegetables. Bind the parsley, basil and thyme together and put it in the pot. Add salt and pepper. Cook the soup over a low heat for approx. 20 min. *Sprinkle pasta or rice and green beans into the soup. Boil the soup around. 15 min. Add peas and continue boiling 3-5 minutes. Remove the herbs.*	
Fish meatballs (source: Good food - easy to do) 400 g fillet of coal fish, cod, salmon or the like. 1 tsp. salt 1 chopped onion (75 grams) 1 egg 2 tbsp. wheat flour or cornstarch 1 ½ dl milk Pepper ½ tbsp. oil 10 g butter or margarine *Remove bones from fish. Cut the fish into smaller pieces and put them in a food processor. Add salt, onion, eggs, wheat flour or corn starch, milk and pepper. Blend coarsely.Form into balls. Heat oil and butter or margarine in a frying pan. Put the fish meatballs in a pan with a spoon and fry until golden at low heat, 3-5 min. on each side.*	
Meat Sauce (source: Good food - easy to do) 500g minced beef 1 tbsp. oil 2 large finely chopped onions 1 finely chopped carrot 100 g finely chopped celeriac or 4 stalks celery 2 tsp. dried oregano 1 tsp. dried thyme ¾ tsp. salt and freshly ground pepper 3 cloves minced garlic 1 can coarsely chopped tomatoes 2 tbsp. tomato paste 3-4 dl beef broth *Fry meat in oil in a large saucepan until it has changed color. Add onions, carrot and celery and continue frying for a few minutes. Add oregano, thyme, salt and pepper. Add the garlic, tomatoes, tomato paste and broth. Let the sauce simmer covered 20 min. and add salt and pepper to taste.*	
Meat balls (source: Good food - easy to do) 500g minced beef and pork ca. 2 dl milk or water 1 dl wheat flour 1 egg 1 tsp. salt ¼ tsp. freshly ground pepper ½ grated or finely chopped onion (50 grams) 25g butter or margarine for frying *Combine all ingredients in a bowl and stir mixture well, possibly with a wand mixer, approx. 3 min. Let the mixture chill in the refrigerator at least 15 min. Mix thoroughly again. If meat is too stiff, add more liquid. Heat the butter or margarine on a frying pan. Dip a table spoon into oil and form meatballs with a spoon and hand. Put them on the pan. Fry meatballs 4-5 minutes on both sides with even heat.*	

Sweet and sour pork (source: Good food - easy to do)
300 g pork meat
Marinade:
1 ½ tbsp. oil
2 cloves garlic, minced
2-3 tbsp. soy sauce
1 tsp. sambal oelek
1 red chilli, minced
4 spring onions or 2 leeks
1 squash (250g)
1 red bell pepper (150 grams)
250 grams of mushrooms
1 can bean sprouts *
½ tbsp. oil
2 tbsp. oyster sauce
Sweet and sour sauce:
½ dl vinegar
2 tbsp. tomato paste
1 dl water or broth
3 tbsp. sugar
1 knife tip sambal oelek
*Cut meat into very thin strips. Mix marinade together. Put the meat into the marinade and let it marinate in the refrigerator approx. 1 hour. Cut spring onions into 2 cm pieces. Cut the squash into strips. Cut the bell pepper into thin strips. Cut mushrooms into thin slices. Drain bean sprouts in a sieve. Heat a wok or sauté pan. Pour on the oil. Add the vegetables - except bean sprouts - and fry until they are ¾ finished, approx. 2 min. - stir constantly. Add bean sprouts and stir. Remove the vegetables and wipe out the wok. Pour meat and marinade into the wok and fry for approx. 2 min. Stir the meat constantly. Return the vegetables to the wok and heat thoroughly approx. 1 min. Add the oyster sauce. Mix sweet and sour sauce ingredients together and pour into the wok. Heat thoroughly approx. 1 min. Season and serve immediately. * Added to the recipe instead of white cabbage.*

Omelette (source: Good food - easy to do)
4 eggs (pasteurized)
4 tbsp. water
¼ tsp. salt,
1 knife tip white pepper
15 g butter or margarine
Whip together whole eggs with water, salt, and pepper with a fork. Melt the butter or margarine on the pan. Pour the eggs on the pan when the butter is golden. Stir eggs until they begin to stiffen. Reduce heat. Loosen omelette along the edges. Shake the pan a back and forth gently to see if the omelette is loose. Otherwise, lift slightly from the pan and slide a little butter underneath. Can be served with various fillings.

Cream Potatoes (source: Good food - easy to do)
1 ½ kg large potatoes
1 clove garlic
75 grams of minced onion
salt and pepper
¼ tsp. grated nutmeg
3 dl cream 9%, or a mixture of milk and cream
Peel the potatoes. Cut them into 2 mm thin slices. Add potato slices in a casserole dish. Add pressed garlic.Disperse chopped onion and sprinkle with spices. Pour cream/milk over. Put the dish in the oven on one of the middle racks. Baking time: Approximately 50 minutes at 200 º C, until all the liquid is absorbed. Feel whether the potatoes are soft.

Marinated potato salad (source: Good food - easy to do) 1 kg small potatoes, preferably new potatoes *Marinade:* 2-3 tbsp. (olive) oil 2-3 tbsp. tarragon or wine vinegar 1 tsp. Dijon mustard 1 chopped onion (100 grams) salt and pepper 2 tbsp. chopped parsley or other herbs *Boil and peal the potatoes. Cut them in not too thick slices. Mix the marinade together. Add potatoes to the marinade. Let potato salad soak at least 10 minutes before serving*.	
Browned potatoes (source: Good food - easy to do) 750 g small potatoes 3 tbsp. sugar 10 g butter *Boil and peal the potatoes. Put sugar in a cold frying pan and melt it at medium high heat until light brown. Add the butter and let it melt. Rinse potatoes in a colander with cold water. Pour them into the hot sugar mass and stir the potatoes until they are brown all over.*	
Mashed potato (source: Good food - easy to do) 1-1 ½ kg piebald potatoes water ca. 2 ½ dl milk 10-20 g butter (optional) ½ tsp. salt and white pepper *Peel the potatoes and cut them into thick slices. Boil the potatoes until soft in water without salt. Pour the water from the potatoes and let steam dry. Mash the potatoes vigorously with a potato masher, hand mixer or whisk. Heat the milk and whip it into the potatoes a little at a time, until it has a suitable consistency. Add butter if desired. Add salt and pepper, to taste.*	
Pancakes / crepes Suzette (source: Good food - easy to do) ca. 4 dl milk 200 g wheat flour (3 ½ dl) 1 tsp. sugar ¼ tsp. salt ½ tsp. cardamom or grated lemon peel 3 eggs 3 tbsp. beer or water butter for baking *Mix all the ingredients or pour liquid into blender or food processor and add the other ingredients. Blend 1-2 minutes. Pour the batter into a pitcher. Let batter chill about ½ hour in the refrigerator. Melt the butter for baking.* *Heat a non-stick pan to medium high. Pour a little butter on the pan. Pour approx. ½ dl of batter onto the pan. Rotate the pan so the batter spreads over the bottom of the pan. Cook the pancake on both sides on even heat until light brown. Lay the pancakes folded together in a baking dish and keep warm.*	
Orange Sauce (source: Good food - easy to do) 15 g butter 50 g sugar Zest of 1 orange 1 dl orange juice 2-3 tbsp. lemon juice ½ dl brandy or Grand Marnier (optional)	

Almond flakes (optional) *Mix everything in a saucepan and boil the sauce for 1 min. Pour in brandy or Grand Marnier just before serving. Ignite! Watch your hair - and hood. Serve when the fire is out - with almond flakes if desired (for pancakes).*	
Orange - or lemon cream (source: Ingeborg Suhr: Mad -1972) 2 egg yolks 2 tbsp. sugar 2 dl milk / cream Seeds of ½ vanilla pod 2-3 sheets gelatine ca. ½ dl orange or lemon juice a little orange or lemon zest *Mix egg yolks and sugar together in a saucepan. Add vanilla and milk or cream, and bring cream to a boil, stirring constantly. Mix in the softened gelatine - Stir well to melt completely. Add orange or lemon juice and zest (optional) - stir. Cool custard, stirring occasionally.*	
Fruit compote (source: Ingeborg Suhr: Food - 1989) ¾ kg fruit (apples, pears, oranges, berries or plums etc) *Syrup:* 3 dl water 125 g sugar lemon juice (optional) *Cut the fruit into pieces (keep berries whole). Bring syrup to a boil over medium high heat. Cook the fruit in the syrup over low heat until just barely soft. Add lemon juice to taste.*	
Caramel Sauce (source: Ingeborg Suhr: Mad -1972) 100g sugar 2 dl water 2 dl Whipping cream *Melt sugar in a frying pan over a low heat without stirring. Avoid burning. Pour boiling water into the pan. Boil water and sugar until melted evenly. Cool the caramel. Whip the cream. Mix caramel and whipped cream.*	
Apple pie (source: Good food - easy to do) *Dough:* 100g butter 125 grams wheat flour 1 egg yolk 1 tbsp. cold water *Filling:* 750 g sour apples 1-1 ½ dl sugar after taste 2 tsp. vanilla sugar ¼ tsp. ground cloves ½ tsp. ground cinnamon Glaze: beaten egg Garnish: 1-2 tbsp. sugar *Mix the butter into the flour. Add egg yolk and water. Mix the dough quickly. Chill ½ -1 hour. Peel the apples, remove the cores and cut them into slices.* *Heat oven to 200 º C. Put the apples in an baking dish and mix in the sugar and spices. Roll out the dough until slightly larger than the dish. Put the dough over the apples. Seal the edges. Cut some air holes with scissors.* *Brush dough with beaten egg and sprinkle with sugar. Bake the pie in the oven on a middle rack for 30-40 min.*	

Apple cake, Denmark (source: Good food - easy to do)
1 portion prepared apple filling (eg. Seongnam) or 1 jar apple sauce - approx. 500g
ca. 30 g butter
15-20 rusks
2-3 tbsp. sugar
2 dl Whipping cream
Currant jelly (optional)
Add rusks in a plastic bag and crush them with a rolling pin into crumbs. Mix with sugar. Melt butter in a pan and roast crumbs with not excessive heat. Stir crumbs constantly. Remove from pan and let cool. Whip the cream. Layer applesauce / filling and crumbs: 3 layers of crumbs and 2 layers of applesauce / filling. Top with whipped cream and jelly.

Syrup Cake (source: JUL from Brugsen)
350 grams (2 ½ dl) syrup
175 g brown sugar
2 eggs
500 grams of wheat flour
1 ½ tsp. soda
4 tsp. cinnamon
1 tsp. cloves
1 ½ dl buttermilk
Heat syrup and brown sugar in a saucepan - let it cool. Mix eggs in. Mix the flour with soda, cinnamon, cloves and mix into the dough alternating with the buttermilk. Pour the dough in a greased baking pan (about 20 x 30 cm). Bake approx. 45 min. at 175 º C on the middle rack.

Cookies (yields 25 -30 cookies) (Source: Karin)
200g margarine
160 grams light brown sugar
160 g sugar
2 eggs
1 tsp. vanilla sugar
240 g wheat flour
4 dl oatmeal
1 tsp. baking powder
1 tsp. soda
160 grams coarsely chopped chocolate (dark)
160 g peanuts, hazelnuts or other nuts (may be coarsely chopped)
Mix margarine and sugar together. Add the eggs while stirring. Mix the other ingredients together and add gradually. Form the dough into large balls with your hands. Press balls flat on baking sheet. Cookies spread out while baking. Bake at 200 º C for 12-15 min.Cool on a cooling rack.

White bread (source: Good food - easy to do)
25 g yeast
½ dl lukewarm water
25 g butter
2 ½ dl milk or water
1 tsp. salt
ca. 500 grams of wheat flour
Glaze: beaten egg or milk
Mix yeast in lukewarm water. Melt butter, add the cold milk and pour the mixture into the yeast. Add salt and ⅔ of the flour. Mix the dough together in a bowl. Put the dough on a floured surface and knead it well with enough flour so it stays soft and smooth. Cover the dough with a lid, plastic film or a wet cloth. Let the dough rise until it doubles in size, approximately. 45 min.
Punch down the dough and form it into a loaf. Put it greased 2 litre elongated bread pan. Cover and let rise in a warm place 10-15 minutes.

Heat oven to 200 º C.Cut across the top of the bread with a sharp knife and brush with beaten eggs. Bake the bread on the bottom rack 40-50 min. Take the bread out and let it cool on a cooling rack.	
Tea Buns (source: Good food - easy to do) 50 g yeast ½ dl lukewarm water 50g butter or margarine 1 ½ dl cold water 2 eggs 1 ½ tsp. salt 1-2 tsp. sugar 100g raisins Citrons (optional) ca. 500 g wheat flour (8-9 dl) Glaze: beaten egg *Mix yeast in lukewarm water. Melt butter, mix it with the cold water, and pour the mixture into the yeast while it is still lukewarm. Add the remaining ingredients and knead the dough thoroughly. Let the dough rise until it has doubled in size, 30-45 minutes. Punch down and divide in two. Separate each half into uniform pieces. Shape each piece into a roll. Let the rolls rise 10-15 min. on a baking sheet lined with waxed paper. Heat oven to 225 º C.* *Brush with beaten egg. Bake for approx. 20 min on the middle rack. Let the rolls cool a bit on a rack.*	
Apple pure with thyme (source: Dansukker) 1 kg apples 1 dl water 6 dl Sugar 1 / 4 tsp. ascorbic acid 1 / 4 tsp. sodium benzoate Thyme *Peel and remove seeds from the apples and cut them into cubes. Boil the apple cubes in water, and mash them. Add ascorbic acid. Add sugar and bring it to boil while stirring. Stir sodium benzoate in a fragment of the mashed apples and mix it into the rest of the apple pure. Add fresh or dried thyme.*