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Acrylamide in Swedish food

– targeted sampling 2011 and 2012

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Summary

The World Health Organization (WHO) classifies acrylamide as probably carcinogenic to humans and assesses that the acrylamide content in heat-processed foods constitutes a potential health hazard. The EU Commission is actively working to find ways of reducing consumers' acrylamide intake. They have, for example, issued recommendations stating that all EU countries should implement monitoring programs and investigations into the acrylamide levels in food.

The Swedish National Food Agency carried out extended sampling and analysis of acrylamide in food during 2011 and 2012 in accordance with the EU's recommendations. The aim was to identify products on the Swedish market containing appreciably higher concentrations than normally found in comparable foods, and to be able to better understand the causes of such concentrations. In particular, the National Food Agency evaluated the extent to which producers had followed the current food industry guidelines on how acrylamide concentrations can be limited.

A total number of 204 targeted products from the Swedish market was investigated in seven different food categories – coffee, french fries, potato crisps, bread, biscuits, breakfast cereal and baby food. Acrylamide concentrations higher than the so-called "indicative values" determined by the EU Commission were found in most of the food categories included. The values are set so that only a small percentage, approximately 5 percent, of the product range in the EU countries is expected to be above the respective value. The different "indicative values" are not formal limit levels but at this stage have only a guiding function in the authorities' work on acrylamide.

Most breaches of the limit value were found in potato crisps and soft coarse bread, where 34% and 18%, respectively, of the products had values higher than the "indicative values". The results show that certain Swedish products/food producers may find it difficult to keep acrylamide concentrations under the approved levels that could come into force if common limit values are introduced. For potato products one cause may be that potatoes grown in Sweden for some unknown reason results in higher concentrations than potatoes grown in many other parts of Europe.

When acrylamide concentrations exceeded the "indicative values", the Swedish National Food Agency carried out follow-up visits of the producers. These visits and other contacts with major Swedish producers give a picture of the companies generally having a high level of awareness and knowledge with regard to the problems surrounding acrylamide. Some companies have disclosed that they have invested a great deal in reducing acrylamide concentrations. However, the Nation-

al Food Agency notes that concentrations have in general not been reduced since regular sampling of acrylamide started in 2005 in Sweden.

It is difficult to assess why, in spite of the efforts made, there has not been greater success in reducing concentrations. One reason that has been given is that it has been difficult to impact acrylamide concentrations without at the same time changing the product's qualities, such as taste, colour and crispiness. With regard to small companies, the National Food Agency does not at present have any knowledge regarding how they view acrylamide and whether they are taking any measures.

As the investigation focused on finding the products with the highest acrylamide concentrations in each food group, the sample of products is not representative of the products available. Furthermore, the investigation only gives a snapshot of acrylamide concentrations in the different products included as each individual analytical result only applies to a single specific production date. The concentrations may vary greatly from time to time in one and the same product, in particular potato products, and the results of the investigation cannot therefore be used as a guide when shopping for food.

Owing to the carcinogenic properties of acrylamide, it is a matter of urgency that the intake of acrylamide is reduced among Swedish consumers. The National Food Agency therefore believes that food producers should intensify their efforts to reduce concentrations. The National Food Agency intends to continue its dialogue with the food industry on how concentrations can be reduced, and plans to carry out a follow-up study of acrylamide concentrations in 2014.

The results of the investigations have been reported to the European authority for food safety, Efsa, and to the EU Commission. The results will be used as a basis for negotiations in the EU Commission's work of drawing up more effective risk management measures, for example common limit values for acrylamide in food.

Introduction

In response to a recommendation[1] from the EU Commission, the Swedish National Food Agency carried out an investigation in 2011 and 2012 of the acrylamide concentrations in food, with follow-up visits to producers when concentrations of acrylamide were found that were higher than indicative values. This report presents data on concentrations found in the investigation, as well as what was ascertained at the follow-up visits carried out.

Background

Acrylamide is a substance, a so-called process contaminant, that is formed naturally when food is cooked. Acrylamide is not present in the raw material, but is formed during heating. This applies in particular to carbohydrate-rich food such as different potato products, bread, biscuits and coffee. Acrylamide is a carcinogenic substance and exposure to acrylamide via food may involve an increased health risk. It is therefore important to reduce concentrations in our food and thus reduce Swedish consumers' acrylamide intake.

Management measures

The work of trying to understand the factors behind the formation of acrylamide when processing raw material for food has been ongoing since its discovery in 2002. The EU Commission has clearly indicated in cooperation and dialogue with the food industry that acrylamide concentrations must be reduced. Various management measures have been introduced in cooperation with member states and the food industry. For example, since 2007 there has been a recommendation that member states carry out annual monitoring programs for acrylamide concentrations in food[2]. Monitoring should focus on those foods that are known to contain high concentrations of acrylamide and/or which largely contribute to human in-

[1] Brussels, 10.1.2011, C(2010)9681.
[2] EUT L 123, 12.5.2007, p. 33.

take via food. The results from the period 2007-2010 have been compiled by Efsa in a scientific report[3].

Via the joint organization FoodDrinkEurope, the food industry has developed a "toolbox" of methods that food producers can adapt to their own specific needs so that they can reduce acrylamide concentrations in their products. The food industry can also consult the "Codex code of practice for the reduction of acrylamide in foods".

The European authority for food safety, Efsa, notes in its compilation of the results from member states' monitoring that acrylamide concentrations are by and large unchanged since measurement of concentrations in food was started. The pressure brought to bear by the EU Commission and the management measures implemented so far have not given the results that had been hoped for. Efsa's results are in agreement with the results of an "indicator study" that the Swedish National Food Agency has carried out annually in Sweden 2005-2013 (Figure 1). The indicator study is a long-term trend study that aims to investigate what effects food producers' efforts to reduce concentrations have had on Swedish consumers' exposure to acrylamide. The results have not shown any clear general change during the years that the study has been ongoing.

Based on Efsa's conclusions, the EU Commission recommends continued monitoring of acrylamide concentrations in food indefinitely[4]. The EU Commission has also established "indicative values", with a recommendation[5] to member states that where these values are exceeded, a follow-up inspection of the producer is to be done to try and understand the causes of the high concentrations.

[3] European Food Safety Authority; Update on acrylamide levels in food from monitoring years 2007 to 2010. EFSA Journal 2012;10(10):2938. [38 pp.] doi:10.2903/j.efsa.2012.2938. Available online: www.efsa.europa.eu/efsajournal
[4] EUT L 137, 3.6.2010, p. 4.
[5] Brussels, 10.1.2011, C(2010)9681.

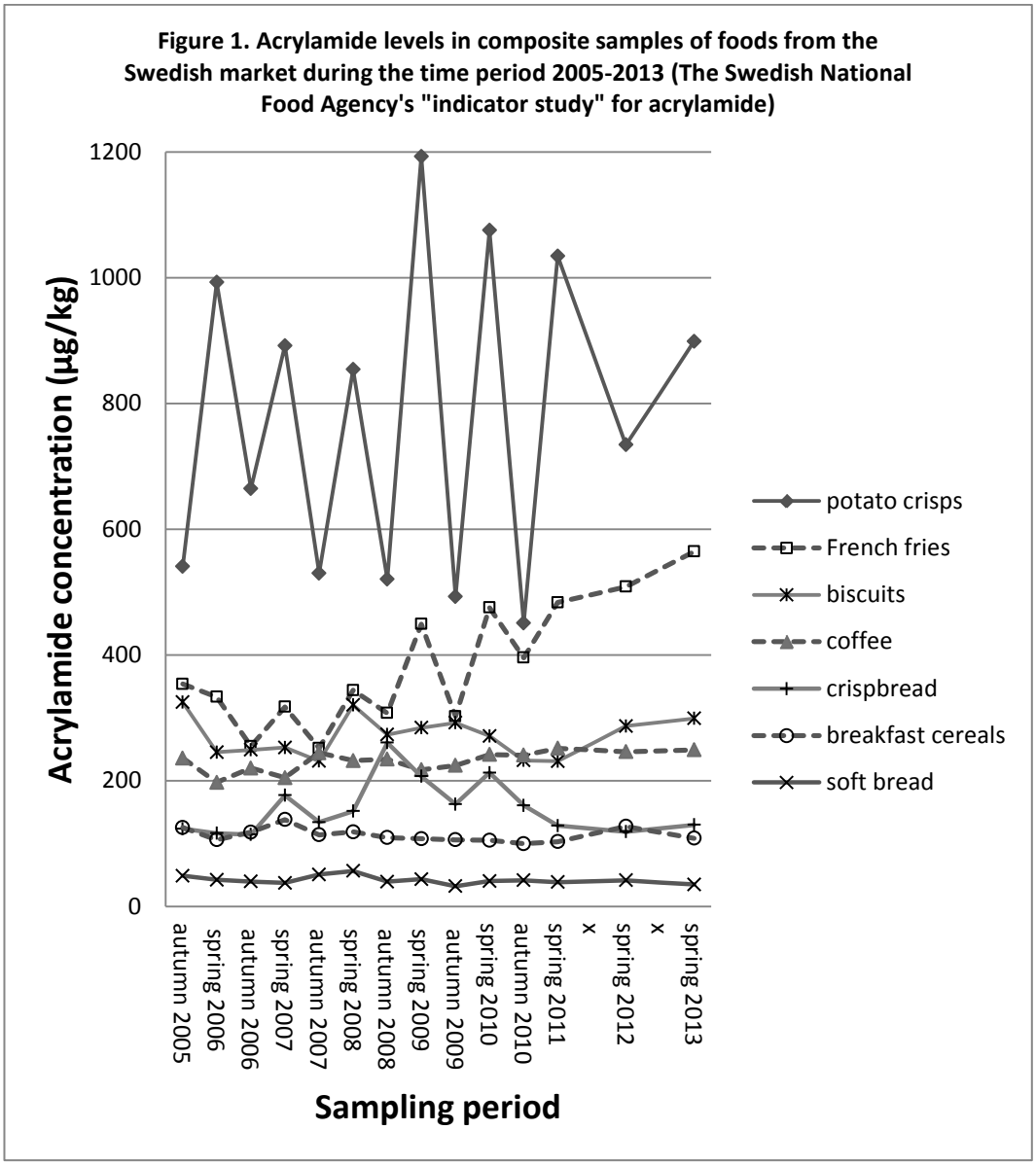

Figure 1. Acrylamide concentrations in composite samples from the Swedish National Food Agency's ongoing trend study concerning changes in acrylamide concentrations in food from the Swedish market during 2005-2013, the so-called "Indicator Study". The acrylamide concentrations given in the figure are average concentrations for the different food categories, which have been produced by combining different food products in composite samples before analysis. A total of approximately 132 different products are included each time sampling is done. Samples of the same products (producer/product name) have been taken on each occasion as far as possible. The results show that concentrations have not fallen in general during the time that the study has been ongoing. The pattern of higher values when samples are taken in spring compared with samples taken the preceding autumn is due to the fact that stored potatoes give rise to higher acrylamide concentrations than the corresponding newly harvested potatoes. Note that only spring samples were taken 2011-2013. The samples for 2011 and 2012 are not the same as those reported in Table 1 and Appendix 1 in this report.

Indicative values

Indicative values are guideline values that have been set on the basis of member states' results from the four years of monitoring that was carried out between 2007 and 2010. When the values were produced on the basis of the 95th percentile of the results, that is to say the values were set at a level where approximately 5 percent of the results from each food category, which contained products from all of the EU, exceeded the value. The aim was thus to find the products/product categories in the European market that for some reason stick out with regard to acrylamide concentrations. Through the follow-up inspections the EU Commission wants to gather information about whether companies are aware of the problem of the formation of acrylamide, whether they know of the management measures that are available, if they follow these and if they take the acrylamide issue seriously.

In November 2013 a revised recommendation was published in the European Union's official journal about investigations into acrylamide concentrations in food. Some indicative values have been lowered and new food categories have been added in comparison with the previous recommendation (ref: 2013/647/EU).

Acrylamide is formed under normal production conditions and from natural substances in the raw material and is therefore difficult to control. How low concentrations it is realistic to achieve varies between different foods. Different "indicative values" have therefore been set for different food categories in relation to how normal concentrations vary.

It should also be pointed out that the different "indicative values" do not have any direct relation to the risk represented by the acrylamide concentrations in the different food categories. The values must not be perceived as a formal limit value or as an "acceptable level" under which concentrations are not harmful. At the present stage the "indicative values" only have a guiding function for the authorities' preparatory risk management work.

The guiding principle behind the management measures for acrylamide is to try to reduce intake at the population level, that is the total long-term intake of the population as a whole. To achieve this it will be necessary to reduce concentrations in food across the board, not just in the categories with the highest concentrations. If limit values are set in the future, this will probably involve different values for different foods, in the same way as for the "indicative values".

General facts on acrylamide

Formation

Acrylamide is to be found above all in vegetable food that has been prepared at temperatures above 120°C, for example by frying, baking and roasting. It is formed through a heat-dependent reaction between sugar and the asparagine amino acid that occurs naturally in all plants.

Since the discovery in 2002 that acrylamide is formed in food, researchers and food producers have carried out a substantial amount of work to map factors in the formation of acrylamide and to find methods to reduce acrylamide concentrations. The list of possible measures is long and covers all the stages from plant breeding and cultivation of the raw material to the ready-to-eat product. Each producer must choose the measures that are best suited to their product, production methods and particular product quality. One difficulty in reducing concentrations stems from the fact that the same type of chemical reactions that give rise to acrylamide also result in the positive changes in taste and colour that we associate with frying.

Health effects

WHO classifies acrylamide as "probably carcinogenic to humans" and assesses that the acrylamide content in heat-processed foods constitutes a potential health risk[6][7]. The risk of contracting cancer depends on the total amount of acrylamide that a person has consumed over a period of many years.

Acrylamide causes permanent genetic damage in both humans and animals. Long-term studies on rats and mice have shown that the frequency of tumours in different organs increases when the animals are exposed to acrylamide. On the basis of these studies attempts have been made to estimate the size of the risk that a human will contract cancer due to acrylamide exposure. The results vary but suggest a risk in the order of 100 to 1,000 cases of cancer per year in Sweden. The estimated cancer risk caused by acrylamide via food should be compared with the background frequency. Cancer is a common disease and approximately 50,000 Swedes are diagnosed with cancer each year.

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[6] Safety evaluation of certain contaminants in food. Ed M Scheffer, WHO Food Additives series 55 (ISBN 92-4-166055-4) /FAO Food and nutrition paper 32 (ISBN 92-5-105426-6), p 1-156, WHO and FAO 2006.

[7] Safety Evaluation of Certain Contaminats in Food. Ed M Scheffer, WHO Food Additives series 63 (ISBN 978 92 4 166063 1) / FAO JECFA monographs 8 (ISBN 978-92-5-106736-9), p 1-152, WHO and FAO 2011.

It is difficult to predict the number of cases of cancer on the basis of results from animal studies. During the past few years a partly new technique called MOE (*Margin of Exposure*) has been developed. This technique compares the amount of a substance that humans consume via food with the amount needed for 10 percent of a group of experimental animals to contract cancer. The less the difference is, the lower the MOE value. A low MOE probably means a higher risk. Acrylamide is the substance in our food that has the lowest MOE of all.

Acrylamide not only increases the risk of contracting cancer, but also causes neurological damage in high doses. Effects such as numbness in fingers and the feet as well as changed sensitivity in the mouth and lips have been observed among people who have been exposed to high concentrations of acrylamide by mistake. It is not likely that such high levels of acrylamide will be reached solely through exposure to food rich in acrylamide.

Intake

Swedes' acrylamide intake from different food groups is described in Figure 2 below. Intake estimates are based on concentration figures from the Swedish National Food Agency's indicator study for acrylamide in Swedish food 2005-2013 together with consumption figures from the Swedish National Food Agency's latest investigation into adult Swedes' food habits, Riksmaten 2010-2011[8].

The National Food Agency's aim in its work on acrylamide is for the long-term intake to decrease for the population as a whole. This means that the focus is not on those foods that have the highest concentrations but rather on those that are the largest contributors to Swedish consumers' long-term average intake.

It can be seen from the figure, for example, that potato crisps account for a lower percentage of acrylamide intake than soft bread in spite of the fact that the average concentration in potato crisps is ten times higher than in bread.

[8] Riksmaten – vuxna 2010-11, Livsmedels- och näringsintag bland vuxna i Sverige, Livsmedelsverket 2012

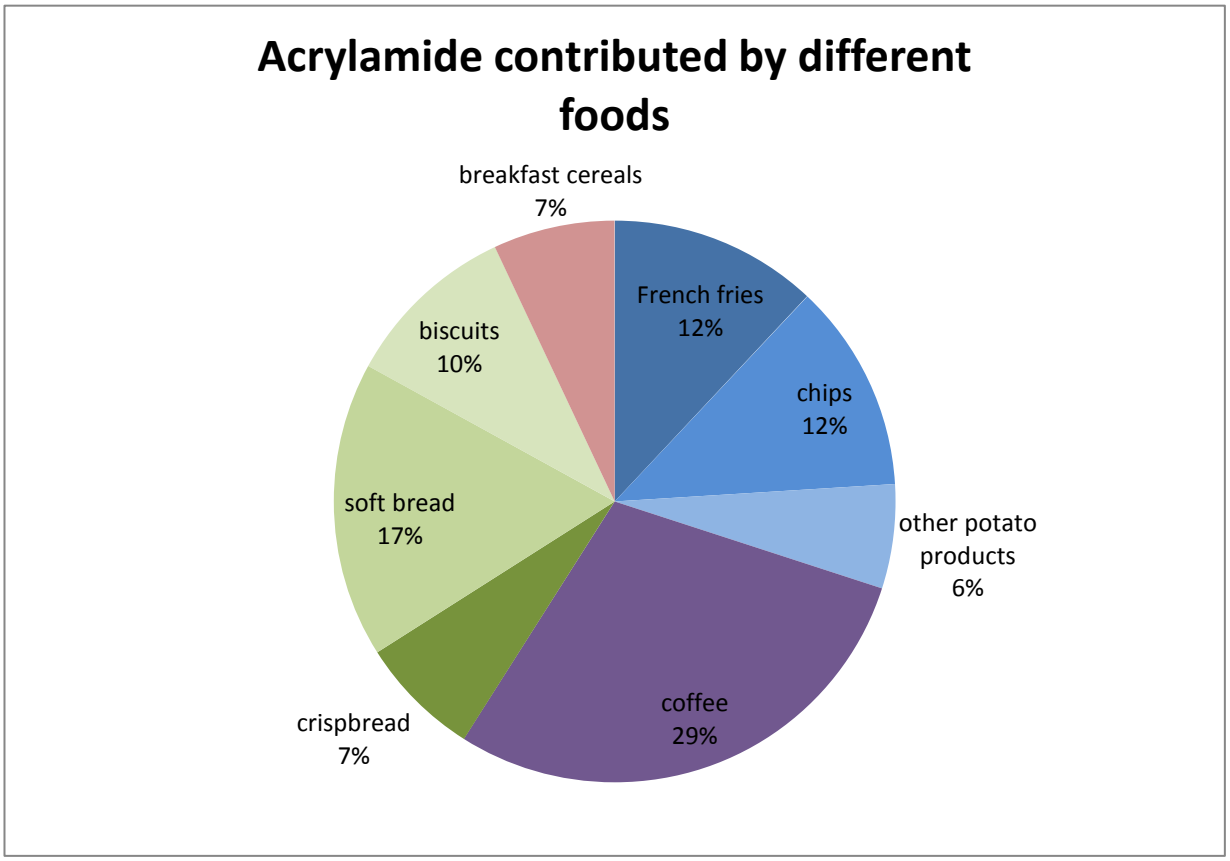

Figure 2. Distribution of the intake of acrylamide from different food groups. Only the most important intake sources are presented in the circle.

The Swedish National Food Agency's advice on acrylamide

Since 2002 the National Food Agency has advised consumers on how to reduce their intake of acrylamide. The advice involves eating a varied diet, avoiding overfried and overgrilled meat, and not eating burnt food. The advice is available on the National Food Agency's website, www.livsmedelsverket.se.

Results

Analytical results and comments

A total of 108 samples were analyzed in 2011 and 96 in 2012. Acrylamide concentrations varied from under the analytical method's detection limit of 5 µg/kg in samples of baby food, gruel and soft bread up to 2831 µg/kg in a sample of potato crisps. The distribution of the samples among different food types is summarized in Table 1 together with summary statistics for acrylamide concentrations. Individual results for all individual samples are reported in Appendix 1, Tables 1-9.

Table 1. Summary of results from the National Food Agency's targeted study into acrylamide concentrations in selected food products 2011/2012

Food group	Number of samples	Acrylamide concentrations[a] (µg/kg)				No. samples above indicative value
		Average conc.	Median conc.[b]	Min-max	Indicative t value[c]	
Coffee (powder)	24 *(7 / 17)*[d]	246	235	155 - 457	450	1
Instant coffee (powder)	2 *(0 / 2)*[d]	793	793	687 - 899	900	0
French fries	19 *(9 / 10)*[d]	349	295	22 - 821	600	3
Potato crisps	35 *(25 / 10)*[d]	960	730	136 - 2831	1,000	12
Soft bread	39 *(19 / 20)*[d]	90	45	<5 -682	150	7
Crispbread	18 *(8 / 10)*[d]	284	169	24 - 1590	500	2
Biscuits	27 *(15 / 12)*[d]	260	179	15 -972	500	4
Breakfast cereal	23 *(15 / 8)*[d]	140	148	23 - 313	400	0
Baby food, jars	13 *(6 / 7)*[d]	51	14	<5 - 260	80	3[e]
Gruel (powder)	4 *(4 / 0)*[d]	11	11	<5 - 19	100	0

[a] All concentrations given are for food ready to eat, with the exception of gruel powder and coffee. The concentration in "normal strength" coffee can be obtained by dividing the analytical value by 19 for boiled or filtered coffee and by 67 for instant coffee.
[b] The median is a calculated "middle concentration", that is half of the samples are under or over this value.
[c] The indicative value is set by the EU Commission as a guideline value for when follow-up investigation work needs to be done. For further explanation, see the Background, Indicative values section earlier in the document.
[d] *(2011/2012)*
[e] Concentrations higher than the indicative value were only found in baby food products containing prunes.

All coffee samples, with one exception, were under the indicative value. The lowest concentrations were, as expected, in the few samples of dark roast coffee included in the investigation. In the National Food Agency's previous investigations (the indicator study) the average concentration was 188 µg/kg in dark roast and 252 µg/kg in medium roast. Coffee is a large source of acrylamide intake in Sweden, but is unfortunately at the same time the product where the lowest number of known measures have been taken so far to reduce concentrations. The manufacturers state that it is difficult to reduce the concentrations in their product without changing its special qualities.

The process involved in the manufacture of instant coffee does not affect the acrylamide. The higher concentrations in instant coffee powder stem from the fact that it is a concentrated form of coffee. The concentration in the final beverage is generally the same as in filtered coffee.

Potato crisps was the product group that gave the highest percentage of results over the indicative value, 34 percent. This was expected as it is already known that Swedish-grown potatoes often give rise to higher acrylamide concentrations than the European average. This is especially the case when the potato has been stored for a long period of time before production. The large variation interval for the potato crisp samples, despite the fact that only Swedish brands were tested, is partly explained by the fact that some Swedish brands of potato crisps are produced in other countries or with imported potatoes, which can give rise to lower acrylamide concentrations. However, Swedish potatoes can also result in very large variations in acrylamide concentrations in one and the same manufacturer due to variations in the stored potato raw material that are difficult to control. Potato crisps' flavouring is normally of no significance for the acrylamide concentration as the the flavouring is added after the frying.

The potato raw material's properties and preparation are also of very great significance for the formation of acrylamide in French fries. Other factors that may have contributed to the variation in concentration in the results are the frying conditions (time and temperature) and the thickness of the potato strips. The concentrations are usually highest in thin, dark and crispy French fries.

Soft bread was the group that after potato crisps gave rise to the most results over the indicative value, 18 percent. Sampling focused on those types of bread that are known to have the highest acrylamide concentrations, that is wholemeal bread and rye bread. In the National Food Agency's previous investigations (the indicator study), the average concentration for white bread was 24 µg/kg and for coarse dark bread 60 µg/kg. Despite the narrow selection of products, acrylamide concentrations in the different bread products varied more than 100-fold in the investigation in 2011/2012.

Biscuits and breakfast cereals are complex product groups where the different products differ considerably in terms of recipe, how they are produced and other factors that can affect the acrylamide content. It has therefore been difficult to give general advice about how the formation of acrylamide can be reduced.The formation of acrylamide can sometimes be related to those factors that also give a certain product its specific taste, texture, appearance etc.

It can be said of all cereal products that wholemeal tends to increase acrylamide concentrations. However, in the assessment of the National Food Agency, the beneficial effects of wholemeal outweigh the risk posed by acrylamide. As cereal products, in particular bread, are a large source of acrylamide intake in Sweden, it is, however, desirable that concentrations are reduced. This must then be done in some other way than through a reduction of the wholemeal content, and consumers are still recommended to choose fibre-rich wholemeal products.

This and other investigations display low acrylamide concentrations in Swedish baby food and gruel. The exception is prune puré. The formation of acrylamide occurs during the drying process in the production of prunes and is thus already to be found in the raw material that baby food producers use.

Results from follow-up visits

The Swedish National Food Agency has now carried out a total of 17 follow-up visits where it was noted that the so-called “indicative values” were exceeded. The companies involved produce products such as potato crisps, bread (soft bread and crispbread), biscuits, baby food and French fries (fast food chains). For facilities where the local authority is responsible for inspections, the follow-up visits have been carried out together with personnel from the local authority.

The National Food Agency’s general perception as a result of the follow-up visits is that most companies have a good knowledge of the problems involved in the formation of acrylamide in the production of their goods. They take the question seriously and are aware of and work in accordance with the so-called “toolbox” that has been produced by Food Drink Europe. The great majority of the companies had identified acrylamide as a hazard in the companies’ hazard analysis. Several companies carried out their own analyses of acrylamide in the products. These analyses could be either sporadic or regular.

It should be pointed out that the National Food Agency’s follow-up visits were in most cases carried out at large industries/companies and that not much is known about small company’s knowledge of acrylamide.

Producer comments on reported acrylamide concentrations

Food producers were invited to submit comments on concentration data in April 2013. Just under ten companies submitted comments.

The comments on the causes of high concentrations can be summarized in a few main points:
-The use of Swedish-grown potatoes. More knowledge and research are needed regarding cultivation conditions and potato varieties.
-For bread more reserach is wanted on the significance of the cereal raw material for the formation of acrylamide.
-Several producers stress that it has been difficult to influence acrylamide concentrations, for example through changes in the recipe, without changing the quality of the product. Many of the proposals in the "toolbox" have therefore been difficult to put into practice.

It is emphasized that large producers apply the food industries' "toolbox" to reduce the formation of acrylamide and that they have taken concrete steps to reduce concentrations. The food industry carries out its own concentration controls and cooperates with suppliers in order to choose raw material that limits the formation of acrylamide.

Comments on the design of the investigation

The main aim of the study was to find the products with the highest acrylamide concentrations in the different food groups. The choice of products is therefore not representative of the range of products that exists, neither the distribution among different producers nor the range of products offered by individual producers. The fact that a certain product is not included in the investigation does not necessarily mean, however, that the product has lower concentrations of acrylamide than those included.

The investigation only gives a snapshot of acrylamide concentrations in the different products included as each individual analytical result refers to one particular production batch/date. The specific analytical value reported for a certain product in Appendix 1 is therefore not necessarily typical of the product in question. Acrylamide concentrations can vary a great deal between different production batches from the same producer. This is due, amongst other things, to natural variations in the composition of the raw materials, which can in turn stem from the fact that cultivation conditions vary both within and between different years. The variation in acrylamide concentrations for one and the same product is usually greatest for potato products and considerably less for coffee and cereal products, for example bread.

For bread, sampling focused in particular on wholemeal bread and bread containing rye flour, as white bread normally contains lower concentrations. As for crispbread, a large number of the makes of bread sampled were those baked without yeast, as fermentation of the dough reduces acrylamide concentrations in the finished bread. Medium roast coffee is overrepresented compared with dark roast coffee as the acrylamide concentration decreases with how much the coffee is roasted. For potato crisps and French fries, the great majority of the samples were taken during the spring and summer as it is known that potatoes that have been stored for a long time give rise to higher acrylamide concentrations than newly harvested potatoes.

Sampling and analytical methodology

The samples were collected by National Food Agency personnel in accordance with Commission Regulation (EC) No 333/2007[9] during the period April 2011 to July 2012. The samples were taken from food stores and restaurants (French fries) in Uppsala, Sundsvall and Nyköping.

The preparation of samples and analysis were carried out at the Swedish National Food Agency (Science Department, Chemistry Division 1). The analytical method[10] has been developed at the National Food Agency and uses liquid chromatography in conjunction with tandem mass spectrometry (LC-MS/MS). The method has an expanded measurement uncertainty of ±14 % for concentrations over 100 µg/kg and ±21 % for concentrations under 100 µg/kg. The limit of quantification, that is the lowest concentration that can be measured, is 5 µg/kg. The laboratory has been accredited by SWEDAC for the analysis in question.

[9] COMMISSION REGULATION (EC) No 333/2007 of 28 March 2007 laying down the methods of sampling and analysis for the official control of the levels of lead, cadmium, mercury, inorganic tin, 3-MCPD and benzo(a)pyrene in foodstuffs. European official journal L88/29 29.3.2007.
[10] SOP acrylamide LCMSMS, electronic supplementary material to: Rosén J, Nyman A, Hellenäs K-E. Retention studies of acrylamide for the design of a robust liquid chromatography-tandem mass spectrometry method for food analysis. *J. Chromatogr. A.*, 2007, 1172, 19-24.

Conclusions

Acrylamide concentrations higher than the "indicative values" set by the EU Commission were found in most food categories included. These guideline values are set for each category so that a certain percentage, approximately 5 percent, of the product range in the EU countries is expected to be higher than the value. There is therefore nothing remarkable about the fact that values in excess of these guideline values were found in the investigation, especially as sampling was focused so as to find products with unusually high concentrations. Nevertheless, the results suggest that certain Swedish products/producers may find it particularly difficult to keep acrylamide concentrations under the approved levels that may come into force if common EU guideline values are introduced. This is particularly true of potato crisps and soft coarse bread, where 34 percent and 18 percent, respectively, of the products exceeded the indicative values.

Since 2002 the National Food Agency has actively taken part in the Swedish food operators' network for acrylamide. In recent meetings the results of the investigation carried out in 2011/2012 have been reported and possible causes of the high concentrations in the investigated foods have been discussed in the group. Opinions have also been submitted in writing. The causes mentioned include the following:

- Swedish potatoes often give rise to a high concentration of acrylamide, and research into growing conditions and new varieties of potatoes is needed.
- The possibility of controlling the formation of acrylamide in bread and cereal products is limited by a lack of knowledge of the importance of the raw material.
- It has been difficult to influence acrylamide concentrations without changing the quality of the product.

When the acrylamide concentration exceeded the "indicative values", the National Food Agency conducted follow-up visits at the producers. These visits and other contacts with major Swedish producers give a picture of companies generally having a high degree of awareness and knowledge with regard to acrylamide. Some companies state that they have invested a great deal of resources to reduce acrylamide concentrations. Many companies also carry out sampling of their own for analysis of acrylamide concentrations in their products. As far as small companies are concerned, the National Food Agency today has no knowledge of how they view acrylamide and whether they are taking any measures.

To summarize, the National Food Agency notes that in general large Swedish food producers have good knowledge of the problems surrounding acrylamide. Concrete, and in some cases successful, measures have also been taken to reduce concentrations. However, it is difficult for the National Food Agency to assess to

what extent the “toolbox” of suggested measures, which the food industry’s joint organization Food Drink Europe has produced, is applied in practice, and how the reduction of acrylamide levels is prioritized over competing aspects such as cost increases and changes in product quality. Despite the efforts that food producers claim to have made, the Swedish National Food Agency notes that in general acrylamide levels have not decreased since regular broad-based sampling of acrylamide started in 2005.

Due to acrylamide’s carcinogenic properties, it is a metter of great urgency that Swedish consumers’ acrylamide intake is reduced. The National Food Agency’s goal for the work on acrylamide is that the long-term intake decreases for the population as a whole. This means that the focus is not primarily on the food categories that have the highest concentrations, but rather on those that make the greatest contribution to Swedish consumers’ long-term average intake, for example bread and coffee. The reductions need to be carried out on a broad front, not just in the individual products with the highest concentrations.

As much of the acrylamide intake comes from ready-to-use food products that are important for Swedish consumers, it is not likely that intake can be sufficiently reduced by measures aimed at consumers in the form of dietary or cooking advice. Effective measures must rather be based on action taken by the food industry and restaurants. The Swedish National Food Agency believes that food producers should intensify their efforts to reduce concentrations in their products. The National Food Agency aims to continue the dialogue with the food industry regarding how reductions can be achieved.

When trying to reduce acrylamide concentrations, the positive effects that certain foods can have on health must not be overlooked. The wholemeal content of bread and other cereal products tends to increase acrylamide concentrations. At the same time, in the assessment of the National Food Agency, the beneficial effects of wholemeal outweigh the risk from acrylamide. However, this does not make it a matter of less urgency to reduce acrylamide concentrations in these products, but the reduction must be achieved in some other way than reducing the wholemeal content. Consumers are still recommended to choose fibre-rich wholemeal products.

The analytical results from the National Food Agency’s 2011/2012 investigation and information from the follow-up visits have been reported to Efsa and to the EU Commission. These and future investigations will, together with results from other member states, be used as a basis for decisions on future management measures, for example common limit values for acrylamide in food.

In November 2013 the EU Commission issued a recommendation that follow-up inspections should be continued for a further two years when the revised indicative values are exceeded. The results from the member states’ investigations in 2011 and 2012 have been evaluated and led to the EU Commission revising the

indicative values. Certain values have been reduced and new food categories have been added in the latest recommendation.

During 2014 the National Food Agency plans to carry out new sampling and analysis in order to follow up acrylamide concentrations in food on the Swedish market. When the indicative values are exceeded, the National Food Agency will also carry out follow-up inspections.

Appendix 1. Analytical results

Table 1. Acrylamide concentrations in coffee ("indicative value": filtered coffee 450 µg/kg, instant coffee 900 µg/kg)

Sample ID	**Producer/brand**	**Product name**	**Acrylamide concentration (µg/kg)**	
			2011	2012
EU A 704	Arvid Nordquist	Classic mellanrost	291	
20120427	Arvid Nordqvist	Classic kok mellanrost		273
20120508	Arvid Nordqvist	Classic Eco mellanrost		202
20120515	Arvid Nordqvist	Classic Gran Dia		253
20120425	Gevalia	Brygg mellanrost		246
20120427	Gevalia	Koffeinfritt mellanrost		249
20120508	Gevalia	Carribean Sunrise		228
20120522	Gevalia	Colombia mellanrost		231
20120522	Gevalia	Kok, mellanrost		214
20120522	Gevalia	Milea		233
EU A 705	Gevalia Kraft	Intensivo extra mörkrost	155	
EU A 706	Ica	Mellanrost	457	
EU A 703	Lindvall's	Mellanrost	204	
20120425	Lindvalls Kaffe	Bryggmellanrost		286
20120427	Lindvalls Kaffe	Brazil		208
EU A 702	Löfbergs Lila	Mellanrost	247	
20120425	Löfbergs Lila	Mellanrost		248
20120427	Löfbergs Lila	Mellanrostat savannah		236
20120427	Löfbergs Lila	Mellanrostat harmoni		219
20120508	Löfbergs Lila	Jubileum dark and fruity		186
20120508	Nestlé	Zoegas Mezzo fyllig mellanrost		216
20120508	Tassimo Gevalia	Tassimo Gevalia original		323
EU A 707	X-tra	Kokkaffe mellanrost	314	
EU A 701	Zoégas Nestlé	Intenzo	186	
20120502	Gevalia	Instant ekologiskt mellanrost		687
20120502	Lindvalls Kaffe	Frystorkat snabbkaffe		899

Table 2. Acrylamide concentrations in French fries ("indicative value": 600 µg/kg)

Sample ID	**Producer/brand**	**Acrylamide concent-ration (µg/kg)**	
		2011	2012
EU A 201 1/9	Burger King, Uppsala city	248	
20120522	Burger King, Uppsala city		312
K1 A/2011/36	Flogstagrillen, Uppsala	292	
20120520	Frasses Rasta, Nyköpingsbro		274
EU A 201 30/8	Kebab House, Uppsala Stora Torget	160	
20120520	Max, Nyköping Gumsbacken		246
20120527	Max, Sundsvall		632
20120522	Max, Uppsala City		444
K1 A/2011/26	Max, Uppsala Kvarnängsgatan	336	
EU A 203	Max, Uppsala Kvarnängsgatan	295	
20120522	McDonalds, Uppsala Forumgallerian		447
20120522	McDonalds, Nyköping västerport		821
20120527	McDonalds, SJ Sundsvall		560
K1 A/2011/22	McDonalds, Uppsala Forumgallerian	570	
EU A 202	McDonalds, Uppsala Forumgallerian	602	
20120527	Sibylla Inn, Sundsvall		133
20120522	Sibylla Ofvandals, Uppsala		214
K1 A/2011/29	Svartbäcksgrillen, Uppsala	28	
EU A 204	Svartbäcksgrillen, Uppsala	22	

Table 3. Acrylamide concentrations in potato crisps ("indicative value": 1000 µg/kg)

Sample ID	**Producer/brand**	**Product name**	**Acrylamide concentration (µg/kg)**	
			2011	2012
EU A 107	Axfood Garant	Sourcream&Onion	1375	
20120603	Axfood Garant	Tunna saltade chips		2387
EU A 105	Coop	Xtra, Sourcream & Onion	384	
EU A 108	Coop	Änglamark, salted	714	
20120617	Coop Änglamark	Chips cream and onion		2735
EU A 113	Lidl	Crusticroc Sour cream&Cheese	136	
EU A 112	Eldorado	Sourcream&Onion	296	
EU A 102	Estrella	Original	1699	
EU A 110	Estrella	Proviant, extra tjocka	1812	
EU A 117	Estrella	Solchips	1350	
EU A 120	Estrella	Double Cheese&chili	2831	
20120613	Estrella	Original potatis chips		214
EU A 118	Euroshopper	Sour cream &Onoins Crinkle cut	199	
20120602	Favorit	Salta chips friterade i solrosolja		510
EU A 111	Gårdschips	Lättsaltade	1228	
EU A 123	Gårdschips	Sourcream&Onion	327	
20120527	Gårdschips	Lättsaltade		1545
EU A 101	ICA	Sourcream&Onion	536	
EU A 109	ICA	Ekologiska chips	988	
EU A 125	ICA	Ekologiska chips	180	
EU A 115	ICA	Delikatesschips Pepparmix	355	
20120603	ICA I Love Eco	Ekologiska chips		755
EU A 114	Jonssons mandelpotatis chips	Svamp&Peppar	2039	
20120522	Jonssons mandelpotatis chips	Creme Fraiche		1150
EU A 104	OLW	Lättsaltade	1614	
EU A 106	OLW	Ugnsbakat Sourcream & onion	364	
EU A 116	OLW	Svenska naturchips, dill&gräddfil	842	
EU A 121	OLW	Dill&gräslökschips	383	
EU A 122	OLW	Svenska naturchips, Sourcream&Onion	879	
EU A 124	OLW	Ugnsbakat Extra crispiga chips	991	
20120527	OLW	Lättsaltade		728
20120515	OLW	Ugnsbakat, sourcream and italian cheese		459
EU A 103	Svenska Lantchips	Original	730	
EU A 119	Svenska Lantchips	Gräddfilschips	141	
20120531	Svenska Lantchips	Gräddfil & lök		715

Table 4. Acrylamide concentrations in soft bread ("indicative value": 150 µg/kg)

Sample ID	Producer/brand	Product name	Acrylamide concentration (µg/kg)	
			2011	2012
20120515	Bageri baronen	Rågare		39
EU A 318	Euroshopper	Ryebread	24	
20120502	Familjen Dafgård	Chiabatta oliv, förgräddad		56
20120522	Familjen Dafgård	Pumpabröd, bakeoff		<5
20120523	Familjen Dafgård	Ciabatta naturell, delbakad		6
EU A 305	Fazer	Frökusar	14	
EU A 307	Fazer	Rund & god original	82	
EU A 315 22 s	Fazer	Rågform	43	
EU A 316	Fazer	Må Bättre	24	
20120423	Fazer	Sviktat fullkorn, tunnbröd		30
20120515	Fazer	Rustika ekologiska råghalvor		47
EU A 317	Fazer	Skivad efterugnslimpa	73	
20120515	Garant	Grovt bröd, lingon		46
20120508	Ica Maxi-bageriet, Uppsala Stenhagen	Rågsiktslimpa		47
EU A 313	Kung Markatta	Fyra sädesslag	17	
20120508	Kung Markatta	Extra grovt rågbröd		42
EU A 302	Polarbröd	Polarkaka	63	
EU A 306	Polarbröd	Rågstyrka	43	
20120423	Polarbröd	Njalla tunnbröd		33
20120508	Polarbröd	Små brytare		45
EU A 303	Pågen	Jättefranska	11	
EU A 304	Pågen	Lingongrova	40	
EU A 308	Pågen	Gott Gräddat	173	
EU A 311	Pågen	Råga	261	
EU A 314	Pågen	Prima Danskt rågbröd	8	
EU A 315 28 s	Pågen	Kavring	682	
20120423	Pågen	Lingongrova special		84
20120423	Pågen	Pågenlimpan		49
20120502	Pågen	Kavring		420
20120502	Pågen	Rågklämmor		133
20120502	Pågen	Gott gräddat		155
20120508	Pågen	Prima danskt rågbröd		141
20120515	Pågen	Lingongrova favoriter		304
20120522	Pågen	Dinkelklämmor		60
20120523	Pågen	Fröjd		160
EU A 309	Schulstad	Danskt rågbröd skovmand	5	
EU A 301	Skogaholm	Skogaholmslimpa	28	
EU A 310	Skogaholm	Det goda Solros rågbröd	7	
EU A 312	Skogaholm	Solklart	29	

Table 5. Acrylamide concentrations in crispbread ("indicative value": 500 µg/kg)

Sample ID	**Producer/brand**	**Product name**	**Acrylamide concent-ration (µg/kg)**	
			2011	2012
EU A 402	Fazer	Runda Björn	117	
20120427	Gränna knäcke	Grännas rymmarknäcke		1590
20120403	Härjedalsbröd	Hällbröd		255
EU A 403	Kavli	Flatbröd	139	
EU A 408	Leksand	Normalgräddat	162	
20120315	Leksands	Minirut		174
20120323	Leksands	Fäbodknäcke, häradsbygden		526
EU A 404	Mjällom	Vetetunnbröd	130	
20120427	Pyramidbageriet	Bayoumy Gourmet, Batanun, solros-, pumpa-, & linfrön		28
EU A 405	Ryvita	Råg	164	
EU A 401	Wasa	Delikatess	309	
EU A 406 *	Wasa	Husman	87	
20120425	Wasa	Delikatess, linfrö		368
20120502	Wasa	Delicate thincrisp, rosemary and salt		24
EU A 407	Vilmas Knäckebröd	Knäckesticks Black&White	385	
20120321	Vilmas Knäckebröd	Vilmas Swedish organic, små bitar rågsurdeg knäckebröd		291
20120427	Vilmas Knäckebröd	Vilmas ekologiska knäckesticks, rosma-rin		129
20120427	Vilmas Knäckebröd	Småbitar husets knäckebröd		232

Table 6. Acrylamide concentrations in biscuits ("indicative value": 500 µg/kg)

Sample ID	**Producer/brand**	**Product name**	**Acrylamide concent-ration (µg/kg)**	
			2011	2012
EU A 504	Annas	Pepparkaka	88	
20120315	Annas pepparkakor	Annas klassiska lantkakor		15
EU A 509	Bisca	Digestive	121	
EU A 515	Euroshopper	Digestive biscuits	134	
EU A 511	Garant	Mariekex	220	
20120315	Gillebagaren	Finskorpor kardemumma		23
20120323	Gillebagaren	Pepparkaksflarn		469
EU A 502	Göteborgs kex	Digestive oliv	342	
EU A 503	Göteborgs kex	Mariekex	358	
EU A 506	Göteborgs kex	Saltiner	177	
EU A 507	Göteborgs kex	Utvalda, Små Digestive	265	
EU A 508	Göteborgs kex	Brago original	191	
EU A 513	Göteborgs kex	Utvalda havssaltade kex	182	
EU A 514	Göteborgs kex	Nya Brago havrekex äpple & kanel	567	
20120315	Göteborgs kex AB	Brago med fullkorn		453
20120321	Göteborgs kex AB	Smörgåsrån original		191
20120321	Göteborgs kex AB	Tom and Jerry		152
20120321	Göteborgs kex AB	Smörgåsrån fullkorn		565
EU A 505	Ica	Digestive	179	
EU A 501	Kung Oscar	Kryddiga pepparkakor	148	
20120321	Nobelbagarn	Havreflarn		169
20120321	Nobelbagarn	Bondkakor		641
20120323	Nobelbagarn	Chokladflarn		55
20120323	Nobelbagarn	Finska pinnar		104
20120405	Nyåkers	Pepparkakor		98
EU A 512	Pally Biscuits	Biscuits Digestive	149	
EU A 510	Royal	Snack Crackers tomato & basil	972	

Table 7. Acrylamide concentrations in breakfast cereals ("indicative value": 400 µg/kg)

Sample ID	**Producer/brand**	**Product name**	**Acrylamide concent-ration (µg/kg)**	
			2011	2012
EU A 610	Coop	Special	91	
EU A 611	Eldorado	Branflakes	145	
20120425	Frebaco	Fullkornshavreringar, naturell		27
EU A 609	Garant	Crunchy naturell	23	
EU A 613	Honey Monster	Kalaspuffar	208	
20120323	Honey Monster Foods	Kalaspuffar		162
EU A 605	Ica	Crunchy jordgubbar & flakes	39	
EU A 612	Ica	Gott liv fullkornsflingor	193	
EU A 602	Kellogg's	Special K	266	
EU A 606	Kellogg's	Multi Grain Loops	35	
EU A 608	Kellogg's	Allbran Plus fiber-on-top	165	
EU A 614	Kellogg's	Allbran regular	313	
20120315	Kellogs	Special K classic		162
20120524	Kellogs	Rice crispies		138
20120323	Lantmännen Axa	Start Naturell		91
20120528	Lantmännen Axa	Axa Havreflakes		148
EU A 603	Nestlé	Cheerios	150	
20120405	Nestlé	Multi Cheerios		174
20120528	Procordia	Paulúns superflingor		51
EU A 604	Quaker	Rågfras	185	
EU A 601	Start	Start naturell	90	
EU A 615	Wasa	4 Crisp mix	278	
EU A 607	Weetabix	Weetabix original	76	

Table 8. Acrylamide concentrations in baby food, jars ("indicative value": 80 µg/kg)

Sample ID	**Producer/brand**	**Product name**	**Acrylamide concent-ration (µg/kg)**	
			2011	2012
EU A 806	HiPP	Äpple & Katrinplommon	8	
EU A 805	HiPP	Potatis, majs och kalkon, fr 6 mån	<5	
20120405	Hipp	Potatis, majs och kalkon, fr 6 mån		<5
20120515	Hipp	Äpple & Katrinplommon		11
EU A 801	Nestlé	Katrinplommonpuré	260	
EU A 803	Nestlé	Biff stroganoff, fr 8 mån	18	
20120321	Nestlé	Katrinplommon, osockrad, fr 4 mån		179
20120323	Nestlé	Biff stroganoff, fr 6 mån		16
20120617	Nestlé	Katrinplommon, osockrad, fr 4 mån		118
EU A 804	Semper	Katrinplommon, med päron, fr 4 mån	10	
EU A 802	Semper	Spagetti m köttfärssås, fr 8 mån	14	
20120315	Semper	Katrinplommon, med päron, fr 4 mån		15
20120323	Semper	Spagetti m köttfärssås, fr 8 mån		8

Table 9. Acrylamide concentrations in children's porridge/gruel powder ("indicative value": 100 µg/kg)

Sample ID	**Producer/brand**	**Product name**	**Acrylamide concent-ration (µg/kg)**	
			2011	2012
K1A/11-189	Nestlé	Mild havregröt	19	
K1A/11-190	Nestlé	Mild fullkornsgröt	17	
K1A/11-188	Semper	Fullkornsvälling	5	
K1A/11-191	Semper	Mild fullkornsgröt	<5	

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