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# Good manufacturing practice (GMP) for French fries low in acrylamide: results of a pilot project

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## Introduction

Acrylamide is a probable carcinogen (1) formed in roasted, baked or fried foods from the free amino acid asparagine with the support of carbonyl compounds, usually reducing sugars. Fried and roasted potato products are of major concern for acrylamide exposure (2) due to high acrylamide contents and widespread high consumption. The World Health Organization (WHO, 3) and the Scientific Committee on Food (SCF) of the European Union (4) stated their concern about a “serious problem” and the SCF called “for urgent research into measures to lower this formation”. Both organizations request measures according to the ALARA principle (as low as reasonably achievable).

A collaboration of the School of Hotel Management Belvoirpark Zürich and the Official Food Control Authority of the Canton of Zurich showed how French fries of culinary optimum quality can be prepared with acrylamide concentrations as low as 40–70 µg/kg (2), i.e. some 5–10 times less than usual so far. Raw materials were standard commercial frozen prefabricates or fresh potatoes with a low content of reducing sugars. Since acrylamide formation is part of the Maillard reaction providing color and flavor typical of the product, a further reduction of the acrylamide content compromised product quality.

The key points in preparing high quality French fries of low acrylamide content were (5):

1. Use of potatoes low in reducing sugars, of intermediate starch content and yellow flesh
2. Cutting sticks of at least 7 mm
3. Extraction of the sticks in standing warm water for some 15 min or blanching in hot water for several minutes

4. Pre-frying in oil (e.g. 2–3 min at 140°C)
5. Frying in oil starting a temperature of about 170°C which then drops to about 145–150°C
6. Stopping frying when crispiness is achieved and the points show slight browning (flavor) – but before onset of general browning.

Aiming at implementing these findings into the practice of professional catering, the Swiss Federal Office of Public Health (SFOPH) and the Official Food Control Authority of the Canton of Zurich carried out a large campaign in the Canton (region) of Zurich. It should motivate and support the gastronomy in producing French fries with less acrylamide, but also provide data on feasibility, possibly for a later introduction of a limit for good manufacturing practice (GMP). The campaign was considered as a pilot project to test the response and to learn for further campaigns in other parts of Switzerland.

The only reference data on French fries available in Switzerland were from a campaign of the Official Food Control Authorities of the Cantons of Neuchâtel and Vaud in April/May 2003 (6). 59 samples of French fries were collected in fast food restaurants, canteens and restaurants. The average acrylamide concentration in the products of the fast food restaurants (8 samples) was 451 µg/kg. After elimination of two extreme samples containing 1320 and 3150 µg/kg acrylamide, the average concentration in the other 49 samples was 240 µg/kg. The latter was clearly below the values found in other countries (e.g. reported in the internet) and might have already reflected some reduction compared to previous times.

### *Outline of the campaign*

Improvements in the preparation of fried or roasted potato products presuppose the involvement of a broad public, i.e. the professional cooks and the consumers of their products as well as the consumers preparing food in private homes. For this reason the support by the media was considered important. In January 2003, these broadly reported on the methods to prepare high quality French fries of low acrylamide content, emphasizing the strong improvement achievable through simple measures. Additional reports on various aspects of acrylamide followed.

In September 2003, the campaign “Pilotprojekt.STOP.Acrylamid” was started by meetings addressing the leaders of the gastronomy as well as the inspectors controlling restaurants and other food producers, presenting the background of acrylamide formation and the consequences for the preparation of French fries. Immediately afterwards the media were informed about the campaign and some 4000 letters sent out to all restaurants and other points preparing French fries. The envelope contained the following items (7):

1. Information letter of the SFOPH
2. Letter of the Official Food Control Authority of the Canton of Zurich
3. A4-page background information about acrylamide and preparing French fries
4. Short instructions intended to be placed in the kitchen.



The letter included an invitation to an information event and to send in a sample of French fries for a free acrylamide analysis. The cooks were asked to prepare French fries of a quality they would like to serve their guests, taking into consideration the recommendations concerning the acrylamide formation; they were not told to strictly follow the recommendations. Questions were added regarding the kind of raw materials used, the size of the potato sticks, the oil temperatures at the beginning and the end of the frying process (as far as known) and the duration of frying. The participants were reassured about confidentiality and that high acrylamide contents would not have negative consequences for them. The results of the analysis were communicated to the relevant producers, and after completion of the campaign, the summarized results were sent to all participants and brought to the attention of the media.

## Results

Over 100 persons participated at the various information events, with a majority from institutional restaurants (hospitals, schools, companies). 157 samples were sent in for analysis. 53 were from institutional restaurants, large hotels and caterers; most restaurants of schools, hospitals and homes participated. None of the fast food chains sent in a sample, perhaps because their frying conditions are defined by their mother companies. 104 samples were from individual (predominantly small) restaurants – from estimated 2000 more or less regularly offering French fries.

The mean acrylamide content of the samples was 97  $\mu\text{g}/\text{kg}$ . Since this result was strongly influenced by a relatively small number of high values (figure 1), the median was substantially lower: 76  $\mu\text{g}/\text{kg}$ . In 63 % of all samples the acrylamide concentration was below 100  $\mu\text{g}/\text{kg}$ ; further 28 % contained between 100 and 200  $\mu\text{g}/\text{kg}$ , and merely 9 % above 200  $\mu\text{g}/\text{kg}$ . The 90th percentile was at 192  $\mu\text{g}/\text{kg}$ .

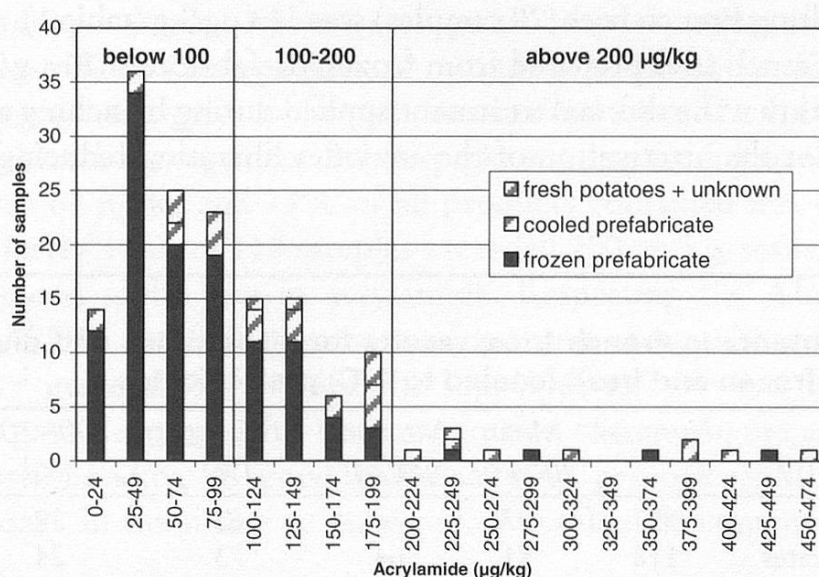


Figure 1 Acrylamide concentrations in the 157 samples sent for analysis

A closer look at the results and additional information from the participants provided further insights regarding the samples with high acrylamide concentrations. Not all samples were prepared according to the scope of the campaign. For instance, a kitchen manager sent in a sample to teach his cook that his product was inadequate (indeed, it contained 355 µg/kg acrylamide). Further, a number of samples were prepared under conditions not corresponding to those recommended. In fact, 14 were fried at (nominal) oil temperatures above 180°C (maximum 197°C). Reasons were either to check whether the conventional way of preparation "was really as bad as everyone says" or that the required efficiency during rush time does not allow for a more time-consuming preparation procedure. Some of these products were indeed high in acrylamide, but several others were between 40 and 80 µg/kg, showing that a careful determination of the end point allows the preparation of French fries low in acrylamide even at very high temperature.

The raw material used was another explanation for high results. Most French fries prepared from fresh potatoes (in figure 1 shown together with samples from unspecified raw material) were high in acrylamide. This suggests that a majority of these potatoes were not of sufficiently low sugar content. For instance, potatoes of the cultivar Sirtema are inherently high in reducing sugar. In two other instances, the potatoes were of the cultivar Charlotte, which are suitable when harvested, but usually brought to cooling rooms early in order to prevent rapid sprouting. The fact that often potatoes of limited suitability were used even during the best period of the year (and despite explanation in the information sent out in the letter) demonstrates the need for a reliable source of potatoes suitable for preparing fried or roasted products.

More important, however, were the high concentrations found in "fresh" (cooled) prefabricates, i.e. products cut, blanched, pre-fried by industry and delivered at 4°C with a maximum storage period of 2 weeks. The mean acrylamide content of the resulting French fries (28 samples) was 163 µg/kg (table 1), which was the double of the French fries prepared from frozen prefabricates (81 µg/kg, 118 products). It suggests that the thermal treatment applied during blanching and pre-frying is insufficient for the inactivation of the enzymes liberating reducing sugar during storage at 4°C.

Table 1

**Acrylamide contents in French fries; results for all samples and divided into the products from frozen and fresh (cooled to 4°C) prefabricates**

	Number	Mean (µg/kg)	Median (µg/kg)	<100 µg/kg (%)	100–200 (%)	>200 µg/kg (%)
All samples	157	97	76	63	28	9
Frozen prefabricates	118	81	64	73	24	3
Cooled prefabricates	28	163	141	36	43	21



### *Further remarks concerning the campaign*

Concerning the success of the campaign, three observations seemed important.

1. The response primarily from the institutional restaurants and other larger producers showed the willingness to react to the newly detected problem. Communication played a key role for this engagement: the repeated presence of the subject in the media had prepared the grounds; most participants knew about acrylamide before the campaign was started, and the deep satisfaction and pride expressed by many confirmed that they were glad about the opportunity to prove their achievement. The fact that less than 10% of the small restaurants participated also showed the limit, i.e. the difficulty to reach these people.
2. Gastronomy is highly sensitive to guests or customers not understanding why French fries should no longer be brown and hopes for the support by information primarily from the media. This information should also work in the other direction: customers should no longer accept brown French fries.
3. The communication of the risk was the most difficult problem: cooks only take extra efforts in preparing French fries when they understand the importance of an improvement; they want to know how many cases of cancer they can help to avoid. Wordings like "the authorities are concerned" are no longer impressing in a time when media report on carcinogenic substances so often.

### **Conclusions**

The campaign had two goals: to engage the gastronomy in preparing French fries with that minimum of acrylamide which cannot be avoided for a product of optimum quality and, secondly, to determine this minimum unavoidable acrylamide concentration.

Concerning the data on acrylamide contents it should be reminded that the samples analyzed are not necessarily representative for the French fries offered by the gastronomy (many were, for instance, not prepared in the stress phase of the rush hours), but for what cooks consider as optimized product, i.e. for what can be achieved. The results largely confirm those obtained from the collaboration with the School of Hotel Management Belvoirpark: starting from frozen prefabricates, the median was 64 µg/kg and 73% of all products contained less than 100 µg/kg acrylamide. Merely 4 out of 118 samples exceeded 200 µg/kg, some of which were not even intended to be low in acrylamide. Respecting the ALARA principle requested by WHO and SCF, concentrations above about 150 µg/kg seem to be avoidable (92<sup>nd</sup> percentile), provided the supply of suitable raw material can be ensured. This provides a basis for the specification of a maximum acrylamide concentration corresponding to good manufacturing practice (GMP), as it might become necessary in the future to enforce low acrylamide contents in the French fries.

The campaign also showed two critical points where further work is needed: the supply of fresh potatoes of ensured suitability for the preparation of French fries (and other fried or roasted products) and the unsatisfactory performance of the cooled fresh prefabricates. This points out the importance of the quality of the raw material: on the one hand, further improvement might well be possible (e.g. through the use of citric acid (8, 9)). On the other hand, shortage in suitable potato might worsen the situation after a poor harvest. The dependence on a natural product might also imply that the acrylamide contents in similarly optimized French fries are different for different regions of the world.

If the results of this campaign could be turned into an every-day-standard, the exposure to acrylamide from French fries could be reduced by a factor of about 5. Since for many consumers the French fries are the most relevant exposure to acrylamide, such an improvement is substantial. It is possible virtually without extra costs.

## Summary

The national and regional health authorities performed a campaign aiming at a reduction of the acrylamide content in the French fries prepared in restaurants of the Canton of Zurich, Switzerland. The information meetings were attended by over 100 persons. Responding to the invitation to send in French fries of optimum culinary quality and low acrylamide content for free analysis, 157 samples were obtained, showing a high response primarily of the institutional restaurants (schools, hospitals, company canteens), larger hotels and caterers. The median of the acrylamide concentrations was 76 µg/kg, and 91 % of all samples remained below 200 µg/kg. Most samples which were relatively high in acrylamide were from potatoes of elevated sugar contents (fresh potato of excessive sugar content or cooled fresh prefabricates) or did not respond to the scope of the campaign. Among the 118 samples prepared from frozen prefabricates, 92 % contained less than 150 µg/kg acrylamide. It is concluded that careful preparation and the use of suitable raw materials enables to prepare French fries containing less than 100 µg/kg acrylamide, which corresponds to an improvement over the conventional products by a factor of about five.

## Zusammenfassung

Das Schweizer Bundesamt für Gesundheit und das Kantonale Labor Zürich führten ein Pilotprojekt zur Senkung der Acrylamidbelastung von gastgewerblich zubereiteten Pommes frites durch. An den Informationsveranstaltungen nahmen über 100 Personen teil. Auf die Einladung, Pommes frites hoher kulinarischer Qualität aus optimierter Zubereitung kostenlos analysieren zu lassen, wurden 157 Proben eingeschickt. Vor allem die Beteiligung der Kantinen, Restaurants von Spitälern und Heimen, grösserer Hotels und Caterer war hoch. Der mittlere Acrylamidgehalt (Median) lag bei 76 µg/kg; 91 % aller Proben enthielten weniger als 200 µg/kg Acrylamid. Die meisten der stärker belasteten Proben stammten aus



Kartoffeln mit erhöhtem Zuckergehalt (rohe Kartoffeln oder gekühlte Frischprodukte) oder entsprachen nicht dem Ziel der Aktion. Von den 118 aus tiefgekühlten Vorprodukten hergestellten Proben enthielten 92 % weniger als 150 µg/kg Acrylamid. Die Resultate zeigen, dass sorgfältige Zubereitung und geeignete Rohstoffe die Senkung der Acrylamidgehalte auf unter 100 µg/kg erlauben, was gegenüber den herkömmlichen Produkten einer Verbesserung um einen Faktor von ungefähr 5 entspricht.

## Résumé

L'office fédéral de la santé publique suisse et le laboratoire cantonal de Zurich ont organisé une campagne visant à réduire la teneur d'acrylamide des pommes frites préparées en restauration. Plus de 100 personnes ont participé aux séances d'information. A l'invitation de faire analyser gratuitement les pommes frites de qualité culinaire optimale produites par une préparation optimisée, 157 échantillons ont été reçus, avec une réponse élevée surtout des restaurants institutionnels (écoles, hôpitaux, cantines d'entreprise), de grands hôtels et traiteurs. La teneur moyenne (médiane) d'acrylamide était de 76 µg/kg, et 91 % de tous les échantillons ont contenu moins de 200 µg/kg acrylamide. La plupart des échantillons présentant une teneur élevée étaient préparées avec des pommes de terre avec trop de sucre (pommes de terre crues ou produits préfabriqués refroidis) ou ne correspondaient pas à l'objectif de cette campagne. Parmi les 118 échantillons préparés de préfabriqués surgelés 92 % contenaient moins de 150 µg/kg acrylamide. Les résultats montrent qu'une préparation soigneuse et une utilisation des matière première appropriée permettent de réduire la teneur d'acrylamide à moins de 100 µg/kg, ce qui correspond à une amélioration d'un facteur d'environ cinq.

## Key words

Acrylamide, French fries, Public campaign, GMP

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