Mycotoxins in the UK Food Supply : Actions Taken to Assess and Reduce Exposure

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Abstract

The Central Science Laboratory (CSL) has been heavily involved over the last decade in carrying out surveillance exercises to estimate the exposure of the population to mycotoxins in the UK food supply. Data produced on behalf of the Ministry of Agriculture, Fisheries and Food for range of mycotoxins important to the UK food supply are given together with the actions taken to reduce exposure to minimal levels. Particular emphasis has been placed on UK studies on patulin in apple juice which is of particular concern to the UK and ochratoxin A in food which is of general concern in the European Union. Regular surveys for patulin in apple juice have been carried out in the UK since 1992. The results and regulatory strategies to reduce exposure are presented. Similarly a number of surveys have been carried out to assess the amount of ochratoxin A in the UK diet. These results and assessments of human exposure through a duplicate diet study are presented, in addition Hazard Analysis Critical Control Point strategies used to reduce contamination of the food supply are discussed.

Key words: patulin, ochratoxin A

Introduction

The UK Ministry of Agriculture, Fisheries and Food (MAFF) has regularly monitored the UK food supply for mycotoxins over the past 20 years. As with all food contamination issues surveillance is usually the first step in obtaining objective information on the scale of a particular problem (Fig 1). When enough information has been gathered it can then be assessed by experts such as the Food Advisory Committee (FAC) and the Committee on Toxicology of Chemicals in Food, Consumer Products and the Environment (COT) to provide advice on estimates of exposure, risk assessment, guideline or prescribed limits and possible control measures. A number of surveys have been undertaken by MAFF since 1980 and the results have been successfully reviewed¹⁾. While the emphasis has been on assessing exposure to aflatoxin during that time other mycotoxins have been also been studied such as patulin, ochratoxin A, trichothecenes, fumonisins, zearalenone, moniliformin and sterigmatocystin. Apart from aflatoxin the main mycotoxins that are currently of particular interest in the UK are patulin and ochratoxin A (OA) and it is these that are discussed in this paper.

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Fig. 1 Monitoring and control strategies for mycotoxins.

Patulin

Patulin is a hemiacetal lactone (Fig 2) which is produced by a number of fungal species of which *Penicillium expansum* is the most important being the principal cause of apple rot and a common pathogen on many fruit and vegetables. *P. expansum* usually infects bruised or insect damaged fruit but can be present when there is no visible evidence of damage. Patulin has been of particular concern in the UK due to relatively high levels that have been found in some UK produced apple juice. A 1992 MAFF survey carried out by CSL revealed a number of high samples (maximum concentration $434 \mu\text{g/l}$)²⁾. The COT has recommended that patulin be considered as a mutagen and stated in 1992 that patulin levels should be reduced to the lowest level technologically feasible, The UK independent Advisory FAC acting on this advice suggested a "Guideline" limit of $50 \mu\text{g/l}$ to which industry should work. As a result The British Soft Drinks Association (BSDA) produced a code of practice in an effort to reduce the possibility of high patulin levels in apple juice. Particular emphasis was placed on the quality of fruit to be used in processing

In addition as from 1992 MAFF has commissioned regular surveys of apple juice and other fruit juices with CSL and other contractors in an attempt to monitor industry compliance with the FAC Guidelines³⁻⁸⁾. The results of these surveys suggested that patulin

Fig. 2 Structure of Patulin

Table 1 Results of 1998 survey on patulin in apple juice.

Type of apple juice	Number of samples in the range ($\mu\text{g/l}$, uncorrected)					
	Tot. No of spls	<5	5-<15	15-34	35-50	>50
Concentrated	101	63 (62)	35 (35)	3 (3)	0 (0)	0 (0)
Directly produced	199	89 (45)	55 (28)	43 (21)	7 (3.5)	5 (2.5)
Total	300	152 (51)	90 (30)	46 (15)	7 (2.3)	5 (1.7)

Concentrations of patulin above 50 $\mu\text{g/l}$ were 54, 73, 113, 125 & 171 $\mu\text{g/l}$. Values in parentheses are percentage of samples in the range.

contamination was particularly associated with "directly produced apple juice" where the juice is produced by direct pressing of the apples as opposed to dilution of concentrate. It is thought that as the directly produced product has minimal processing and can be sold at the "farm gate" unpasteurised or lightly pasteurised it is particularly prone to patulin contamination. Later MAFF surveys have focused on this type of juice. The results from the 1998 survey (Table 1) clearly show an improvement from 1992 with only 5 out 300 samples being above guideline levels, however all of the samples above 50 $\mu\text{g/l}$ were from directly produced apple juice.

Ochratoxin A (OA)

Ochratoxin A (Fig 3) is a secondary metabolite produced by *Penicillium verrucosum* and a number of species of *Aspergillus* of which *A. alutaceus* is best known. OA is nephrotoxic and possibly genotoxic. It is particularly associated with post harvest contamination of foods and feeds. The European Union has initiated a series of initiatives to obtain estimates of exposure. A Scientific Co-operation of the European Commission (SCOOP) project was commissioned to obtain data from Member States on intake levels and estimates of exposure⁹. In 1995 and 1998 The European Commission's Scientific Committee for Food was asked to produce an opinion on OA. The 1998 opinion suggested that OA exposure should be below 5 ng/kg b.w./day¹⁰⁻¹¹. IARC had earlier classed OA as 2B, a possible human carcinogen¹².

OA derived from *Penicillium verrucosum* is commonly associated with stored cereals and is of particular concern to Northern European countries, whereas *A. alutaceus* is more commonly associated with products from warmer climates such as green coffee and spices. Table 2 demonstrates the variety of foods and feedstuffs subject to OA contamination as well

Fig. 3 Structure of ochratoxin A.

Table 2 Natural occurrence of OA in foods and feeds of plant origin.

Commodity	Country	no. of Samples analysed	Percent contaminated	Ochratoxin A level (range, $\mu\text{g/kg}$)
FOODS				
Maize	USA	293	1.0	83-166
Wheat (red spring)	USA	286	2.8	15-155
Barley (malt)	Denmark	50	6.0	9-189
Coffee beans	USA	267	7.1	20-360
Bread	UK	50	2.0	210
Flour	UK	7	28.5	490-2900
Rice	Japan	2	not given	230-430
Beans	Sweden	71	8.5	10-442
FEEDS				
Mixed feeds	Poland	203	4.9	10-50
Barley, oats	Sweden	84	8.0	16-409
Wheat, hay	Canada	95	7.4	30-6000
Wheat, oats, barley, ray	Canada	29	62.0	30-27000
Barley, oats	Denmark	33	57.6	28-27500

Table 3 1996/7 UK Surveillance data for OA in retail foods.

Sample Type	No. of samples analysed	No. of samples in the range ($\mu\text{g/kg}$)					Max. level OA ($\mu\text{g/kg}$)
		<0.2	0.2-4	4-10	10-30	>30	
Barley	37	34	2	1	—	—	6.4
Butter beans, dried	12	11	—	—	1	—	13.7
Cocoa powder	20	3	17	—	—	—	1.1
Currants	20	1	6	8	3	2	53.6
Dates, dried	20	19	1	—	—	—	0.2
Oats	18	17	—	1	—	—	5.9
Pork liver sausage/ pate	10	9	1	—	—	—	0.2
Raisins	20	3	13	3	1	—	20.0
Red kidney beans, dried	17	16	—	—	1	—	15.4
Rye	22	21	1	—	—	—	1.1
Sultanas	20	3	9	4	4	—	18.1
Wheat	76	74	2	—	—	—	2.4
Wine, red	10	6	4	—	—	—	1.1

as the wide range of concentrations of OA found. Results of surveillance carried out CSL for MAFF revealed dried fruit as a potential source of OA contamination (Table 3) and possibly an important source of dietary intake¹³⁻¹⁴⁾

In an effort to obtain more reliable estimates of intake and exposure we have undertaken a duplicate diet study for OA, commissioned by MAFF, involving 50 human volunteers. Five samples of duplicate diet, plasma and urine were taken from each volunteer during a four week period and initially analyzed as bulked samples. Each volunteer kept a diary of his/her eating schedule and content. The main goals of the study were: to assess dietary exposure from foods; measure apparent exposure to OA from blood analysis;

compare exposure with TDI ; establish validity of urinary biomarkers ; confirm relationship between plasma levels and food intake, and identify food sources responsible for high OA levels in blood. Sensitive methods have been developed incorporating immunoaffinity cleanup and post column derivatisation to permit the low level determination of OA required for the project : diet (Limit of Detection = 1 ng/kg), plasma (0.01 ng/ml) and urine (0.01 ng/ml). Although the work is still on going preliminary results reveal OA was detected in all plasma samples (range 0.15–2.17 ng/ml) and diet samples (10–115 ng/kg) and the majority of urine samples (0.01–0.054 ng/ml). Plasma OA levels were similar to levels reported elsewhere in Europe. Other observations from the first phase of the project were that males consumed more OA than females, vegetarians consumed more OA than meat eaters but did not have higher OA levels in their plasma, older subjects had relatively higher levels of OA in their plasma but lower levels in their urine. Work is in progress to analyze the individual weekly samples in an attempt to improve on the correlations that have emerged and to identify OA sources in the diet.

Work has also been commissioned by MAFF to conduct HACCP studies on cereal production to establish critical points in the production which are responsible for OA formation. Similar studies are taking place by other organizations for OA in dried vine fruit and OA in coffee. It is likely that greater emphasis will be placed on establishing HACCP type procedures for food production in the future as a means of controlling the occurrence of mycotoxins in the food supply. It is probable that the EU having obtained data on exposure, risk assessment will set limits for OA in selected commodities in the near future.

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