COMMITTEE ON TOXICITY OF CHEMICALS IN FOOD, CONSUMER PRODUCTS AND THE ENVIRONMENT

COT STATEMENT ON A COMMERCIAL SURVEY INVESTIGATING THE OCCURRENCE OF DISINFECTANTS AND DISINFECTION BY-PRODUCTS IN PREPARED SALADS

Introduction

1. Wash aids, such as those employed by salad manufacturers, were first discussed in February 2005 due to the concern about the potential generation of by-products on or in foods as a result of the use of chlorine-based disinfectant wash-aids. There is currently a lack of information in the scientific literature on the formation of such by-products.

2. In June 2006, the Food Standards Agency (FSA) received the results of a study conducted on behalf of the Fresh Prepared Salads Producer Group, investigating the occurrence and formation of disinfectants and disinfection by-products in prepared salads.

3. The Fresh Prepared Salads Producer Group study is not extensive but is the only available survey of the occurrence and formation of disinfection by-products in prepared salads. The COT was asked to consider the results of this study, in order to allow the FSA to formulate the appropriate consumer advice on the safety of wash aids and to consider whether further work is necessary.

Background

Chlorine wash aids

4. Chlorine washes can currently be used for non-organic fruit and vegetables in the UK provided they meet the legal definition of a processing aid, i.e. they should not perform a function in the final product and should leave no residues that present a health risk. It is the responsibility of producers to ensure food is not injurious to health. Because legislation on processing aids has not yet been harmonised in the

European Union, national legislation applies and processing aids legally used in the UK may not be permitted in other countries and vice versa.

5. UK water supplies contain no more than 1 mg/L of free residual chlorine and typically contain less than 0.5 mg/L (WHO, 2003). Chlorine is added to water as either gaseous chlorine (Cl_2) or hypochlorite (OCl^-). Chlorine washes are typically employed post-harvest to remove debris and dirt; to reduce microbial contamination; and to retain optimal appearance once packaged (Baur *et al.*, 2005; Delaquis *et al*., 2004; and Ong *et al.*, 1996). The procedure for salad washing varies around the world and between producers, but in the UK typical hypochlorite wash practices involve a 1 to 2 minute washing time with 15-20 mg/L free chlorine, as measured at the end of the wash system (personal communication, Bakkavor (Geest)). Following thus, the wash process generally incorporates a final rinse in chilled water with 2-4 mg/L free chlorine or in mains water, followed by a spin cycle to remove excess water.

6. Safety considerations for foods such as prepared salads most frequently focus on microbiological risks. However, concerns have occasionally been expressed about the potential generation of by-products on or in foods as a result of the use of chlorine-based disinfectants as wash aids.

Generation of disinfection by-products

7. Reaction of chlorine-based disinfectants with organic matter in water can result in the formation of a number of by-products, including trihalomethanes, haloacetic acids, haloacetonitriles, haloketones, chloral hydrate and chloropicrin. The presence of bromide can lead to brominated and mixed chlorinated/brominated compounds. Ozonation can lead to non-halogenated by-products, such as aldehydes (e.g. formaldehdye), ketoacids and carboxylic acids.

8. In November 2004 the COT reviewed evidence for associations between chlorinated disinfection by-products and adverse reproductive outcomes (statement available at: http://www.advisorybodies.doh.gov.uk/cotnonfood/chlorination.htm). The COT concluded that the data evaluated did not show a causal relationship between chlorinated drinking water and adverse pregnancy outcomes. However, the COT did recommend further research, particularly prospective studies, to reduce uncertainties in the interpretation of reported associations between patterns of drinking water intake and the incidence of adverse reproductive outcomes. This is the first time the COT has been asked for advice on other possible effects of disinfection by-products.

9. Similar by-products may be produced in or on foods treated with chlorine-based disinfectant wash-aids. There is no published research investigating the occurrence and formation of disinfectants and disinfection by-products

in prepared salads. As such, there is generally a lack of information on exposure to disinfection by-products in pre-packed foods.

Future trends

10. The FSA has been informed that many salad manufacturers are now using water treated by other processes; and it is anticipated that within the next two years, all salad manufacturers will have moved away from chlorination wash processes (personal communication, Bakkavor (Geest)). Current alternative wash options include borehole/spring water (only relevant where producers have 'unlimited' access to water), peracetic acid and products based on extracts of citrus fruits.

Toxicology of Chlorinated By-Products

11. In 2000, IPCS reviewed the formation and risk characterisation for disinfection by-products in drinking water (IPCS, 2000). The evidence was either insufficient or inconclusive to support a link between bladder and colon cancer and long-term exposure to chlorinated drinking water, trihalomethanes or chloroform. In addition, they found no increased risk of cardiovascular disease or adverse pregnancy outcomes associated with chlorinated water (IPCS, 2000).

12. The International Agency for Research on Cancer (IARC) has evaluated a number of drinking water disinfectants and contaminants (IARC, 1991, 1999 and 2004). These include: chloramine, trichloroacetic acid and sodium chlorite (Group 3, *not classifiable as to their carcinogenicity to humans*); and dichloroacetic acid, potassium bromate and chloroform (Group 2B, *possibly carcinogenic to humans*).

13. The World Health Organization (WHO) has similarly evaluated a number of disinfectants and disinfection by-products in the 3rd edition of the Guidelines for Drinking Water Quality (2003). Tolerable daily intakes (µg/kg body weight/day) have been derived for: chlorite (30), chlorate (30), total chlorine (150), chloramine (94), chloroform (15), and trichloroacetic acid (32.5).

Fresh Prepared Salads Producer Group's Study

14. Members of the Fresh Prepared Salads Producer Group, which include Bakkavor (Geest), Nature's Way Foods, Vitacress Salads, Florette and Kanes Foods, recently carried out a programme of testing to identify which, if any, by-products were present in prepared bagged salads and to

re-confirm the safety of their products (personal communication, Bakkavor (Geest)). The programme of testing was managed by Bakkavor (Geest) and performed by ALcontrol Laboratories in early 2005. It represents a limited, initial study; and was neither influenced nor funded by the FSA.

15. The testing programme involved analysing a range of prepared salads, purchased from various retail outlets for the presence of specific disinfectants and disinfection by-products; i.e. various types of prepared salads from a number of manufacturers were tested. Although not a comprehensive study, the selection of salads was reported to be random and representative of the UK salad market. The range of potential disinfectants and by-products analysed for, included: chlorite, chlorate, bromate, free and total chlorine, chloramine, chloroform, total trihalomethanes, trichloroacetic acid and dichloroacetic acid.

Test method

16. The test method was devised by ALcontrol Laboratories and involved steeping the salad in water, followed by testing of the leachate. The laboratory considered that the simple molecules being sought were most likely to be readily leachable from the surface of the leaves. In addition, they suggested that releasing the plant cellular material could lead to complex reactions with some of the analytes and possibly lead to loss of volatile analytes. In order to simulate consumer exposure, bagged salads were purchased off the shelf, refrigerated overnight and tested following addition of 300ml to every 100g bag and a one hour agitation. This 3:1 (water:leaf) ratio was established as the most suitable method, following a series of trial tests with different ratios. It should be noted that this was an empirical method, deemed to be the most suitable at the time, providing adequate detection limits whilst preventing break-up and break-down of the salad leaves.

Test results

17. The results are presented in Table 1 as µg chemical/kg lettuce salad. In the majority of samples tested, the levels detected were low enough to comply with drinking water standards. In one exception, the combined level of trichloroacetic acid and dichloroacetic acid (83.3 µg/kg) exceeded the 60 µg/L permitted by US drinking water regulations for total haloacetic acids (in this case, there are no UK Regulations). However, in all samples, all compounds analysed were within the WHO Guidelines for Drinking Water Quality, where available. In addition, for all samples, estimated ingestion of each compound, based on salad consumption data, was at least several orders of magnitude lower than tolerable daily intakes set by WHO (Table 2).

The table of results presented below has been provided by the study group for this statement. Various drinking water regulations have been included in the table for comparison.

Table 1: Results for disinfectants and disinfection by-products measured in 12 samples of prepared salads

	Chlorite [µg/kg]	Chlorate [µg/kg]	Bromate [µg/kg]	Free chlorine [µg/kg]	Total chlorine [µg/kg]	Chloramine [µg/kg]	Chloroform [µg/kg]	Total THMs [µg/kg]	TCA [µg/kg]	DCA [µg/kg]
UK Drinking Water Limit, 2000		700	10					100		
US Drinking Water Limit, 2004	1000		10		4000			80		60
US max. limit for drinking water systems				4000						
WHO Guidelines for Drinking Water Quality, 1993 (2003 values in brackets)	200 (700)	n/a (700)	25 (10)		5000 (5000)	3000 (3000)	200 (300)		100 (200)	50 (50)
Sample 1	<200	<300	<6.0	700	700	<500	<10	<10	<2.4	<4.0
2	<200	<300	<6.0	700	700	<500	<10	<10	<2.4	<4.0
3	<200	<300	<6.0	500	500	<500	<10	<10	<2.4	<4.0
4	<200	<300	<6.0	<500	<500	<500	<10	<10	<2.4	12
5	<200	<300	<6.0	1000	1000	<500	<10	<10	15.6	<4.0
6	<200	<300	<6.0	<500	<500	<500	<10	<10	23.2	7
7	<200	<300	<6.0	<500	<500	<500	<10	<10	4.5	<4.0
8	<200	<300	<6.0	<500	<500	<500	<10	<10	2.7	<4.0
9	<200	<300	<6.0	800	900	100	16	16	51.3	32
10	<200	<300	<6.0	<500	<500	<500	<10	<10	5.9	<4.0
11				<300	<300	<300	<10	<10	<2	<2
12				<300	<300	<300	<10	<10	3.4	9.6
Samples exceeding limit	0	0	0	0	0	0	0	0		1

The 'less than' (<) values represent limits of detection. These may vary between samples because this was a non-standard method that had never been run before and as such, these limits of detection were estimated.

When this study was conducted, the 2nd edition of the WHO Guidelines for Drinking Water Quality (1993) were in operation. However, the 3rd edition of the Guidelines (2003) has since been published; and hence both the 1993 and 2003 guideline values are provided in the table below (with the 2003 guideline values in brackets).

Table 2: Estimated intakes of each compound for average and extreme cases of salad consumption

Compound	WHO TDI (µg/kg bw/day)[1]	Maximum average concentration in salad (µg/kg salad)[2]	Amount ingested based on salad intake data (µg/kg bw/day)[3]	
			Average adult consumer	High level adult consumer
Chlorite	30	<200	0.0429	0.1611
Chlorate	30	<300	0.0644	0.2416
Bromate	-	<6	0.0013	0.0048
Total Chlorine	150	<575	0.1234	0.4631
Chloramine	94	<433	0.0930	0.3487
Chloroform	15	<10.5	0.0023	0.0085
Total Trihalomethanes	-	<10.5	0.0023	0.0085
Trichloroacetic acid	32.5	<9.85	0.0021	0.0079
Dichloroacetic acid	-	<7.55	0.0016	0.0061

[1]World Health Organization Tolerable Daily Intake (TDI), where available, expressed as µg compound per kg body weight per day (WHO, 2003).
[2]Although this value represents an average of the 10-12 samples tested, it is affected by a large number of non-detect values; and therefore is upper bound and represents an over-estimation.
[3]Calculated on a µg/kg body weight/day basis, assuming a 60kg adult and salad consumption levels of 12.9g/day for an average adult consumer or 48.3g/day for a 97.5th percentile adult consumer. The high intake level was taken from the 1993 Vegetarian's survey as intakes for vegetarians are slightly higher than for the general population (MAFF, 1996). The average intake level was taken from the 2000-2001 NDNS survey (Henderson *et al*., 2002).

COT Conclusions

18. Members noted that in a 150g bag of salad, there would be less chlorine and chlorination by-products than is permissible in a 250ml glass of tap water.

19. Members agreed that the results from this study did not indicate any cause for concern with respect to the presence of chlorination by-products in prepared salads.

20. Given the current trend away from chlorination processes, Members agreed that there is no need for the generation of additional data to confirm the results of this commercial study. However, the new, alternative wash options will need to be kept under review in the future.

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