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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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DISCUSSION PAPER ON OCHRATOXIN A IN COCOA

Governments and international organizations are invited to submit comments on the following subject matters no later than 1 March 2007, preferably in electronic format, for the attention of Ms. Tanja Åkesson, the Netherlands Secretariat of the Codex Committee on Contaminants in Foods, Fax No.:+31 70 3786141; E-mail:info@codexalimentarius.nl with a copy to the Secretary, Codex Alimentarius Commission, Joint FAO/WHO Food Standards Programme, Viale delle Terme di Caracalla, 00153 Rome, Italy (Fax +39.06.5705.4593; E-mail: Codex@fao.org).

BACKGROUND

1. The Codex Committee on Food Additives and Contaminants (CCFAC), at its 38th Session, agreed to establish an electronic working group led by Ghana to develop a discussion papers on OTA contamination in cocoa for consideration at the First Session of the Codex Committee on Contaminants in Foods (see ALINORM 06/29/12 para.145).

2. The electronic working group prepared this discussion paper, which would be a basis for a decision on the potential need for a code of practice to reduce and manage the incidence of OTA in cocoa. Brazil, European Community, Ghana, Indonesia, Switzerland, the United Kingdom and the United States participated in the electronic working group.

INTRODUCTION

3. Ochratoxin A has been found to occur naturally in plant products such as beans, cereals, cocoa, coffee, dried fruits, grapes, pulses, soybean and spices, and also in their industrial derivatives worldwide[34, 44, 50, 51]. In cocoa, OTA is mostly associated with cocoa bean shells and fat-free cocoa solids (cocoa powder)[2, 30].

4. Cocoa is a fermented dried fruit product. Both fungi and OTA can be present in all stages of the production chain: Harvest, fermentation, drying, storage, food elaboration and transport[18, 26]. Cocoa beans are not eaten as such; they undergo industrial conversion before consumption. Cocoa is a very important ingredient in several kinds of foods, such as cakes, biscuits, child-foods, ice creams and sweets[58].

5. During industrial processing of cocoa the first steps are roasting and removal of the shell fraction. The process is not 100% efficient; about 2% of the total cocoa nib weight is due to the presence of shells during the manufacturing process[1].

6. Around 71% of the world supply of cocoa beans comes from West Africa, especially Cote d'Ivoire, Ghana and Nigeria. Cocoa is also produced in Asia and Latin America (see Annex 1)[35]. Being a crop produced by smallholders, cocoa is a valuable non-perishable cash crop for hundreds of thousands of farmers in the cocoa producing countries, and it is also of great importance to the economies of these countries. Most of the cocoa beans are exported to Europe and N. America to be made into cocoa liquor, cocoa butter and cocoa powder.

7. Cocoa is grown in a 20^{o} belt north and south of the equator. The minimum mean temperature in most cocoa growing regions is 18^{o}C, and the mean maximum temperature 32^{o}C. A high rainfall of 1000-4000 mm/year is required. *Theobroma cacao* (cocoa tree) grows well in a wide range of soils.

CHEMICAL STRUCTURE

8. Ochratoxin A (7-(L-b-phenylalanyl-carbonyl)-carboxyl-5-chloro-8-hydroxy-3,4-dihydro-3R-methyl isocumarin) is a secondary metabolite of several species of *Aspergillus* and *Penicillium*[50], which may be present in foodstuff even when visible mould is not seen. OTA is a colourless crystalline compound that is soluble in polar organic solvents and dilute sodium bicarbonate solution and slightly soluble in water[55].

9. OTA is produced by a number of fungal species of *Aspergillus*, most notably *A. carbonarius*, and *Penicillium viridicatum* in cocoa bean at a minimum water activity (Aw) of 0.85[3, 46]. The mammalian enzyme carboxypeptidase A has the ability to cleave OTA into nontoxic products (ochratoxin alpha and phenylalanine)[56].

10. OTA keeps its stability during most food processing stages such as cooking, washing, fermenting to an appreciable degree which can be detected in manufactured food products[4]. Boudra[9] has shown that OTA is heat stable and max 20% of OTA in wheat was decomposed by dry heat at 100^{o}C for 160 min or 150^{o}C for 32 min. During roasting of cocoa the final bean temperature reaches 100 – 120^{o}C and the duration is 15-70 min[43], therefore roasting is not expected to significantly reduce OTA levels.

TOXICOLOGICAL EVALUATION

11. OTA is classified as a possible human carcinogen (group 2B)[19, 36]. OTA has been reported to be nephrotoxic, immunosuppressive, carcinogenic and teratogenic in animal studies[38, 39, 48, 54, 59]. OTA is thought to be the cause of two chronic diseases, Balkan Endemic Nephropathy and Chronic Intestitial Neprhopathy (in North Africa), and of urothelial tumours in humans[48]. A link between OTA exposure early in life and testicular cancer has been hypothesized, based on epidemiological associations[57]. Previous National Toxicology Program (NTP) studies in the United States showed that OTA can induce renal tumours in rodents at high doses[8].

12. Recent scientific evidence cited by Commission Regulation 1881/2006[21], indicated that the site-specific and renal toxicity as well as the DNA damage and genotoxic effects of OTA, measured in various in vivo and in vitro studies, are most likely attributable to cellular oxidative damage. Thus, on the basis of the lowest observed adverse effect level (LOAEL) of 8 ug/kg bw/day for early markers of renal toxicity in pigs, and applying a composite uncertainty factor of 450 for the uncertainties in the extrapolation of experimental data derived from animals to humans as well as for intra-species variability, a TWI of 120 ng/kg bw was derived for OTA. Current levels of exposure to OTA in EU member states vary between15 and 60ng/kg bw/wk[22].

13. The Panel[21] also recommended that more specific exposure data be collected for certain vulnerable groups, including infants and children and those that consume large amounts of certain regional specialities containing OTA.

SAMPLING

14. Variability in OTA production, combined with the large particle size of some of the foods it contaminates, complicate sampling strategies for detection of ochratoxins[15]. A few, highly contaminated grains can raise the level of a whole shipment above the allowed limit, if the limit is low. However, many sampling strategies are not designed to detect these few, highly contaminated grains[15]. Thus development of low-tech, inexpensive methods for mycotoxin surveillance is a world health imperative[47].

15. A Directive prescribing sampling and methods of analysis, Commission Regulation 401/2006[20], has been introduced for various foodstuffs. There is no special sampling plan for cocoa.

16. Procedures/regulations are available in Europe for the sampling of bulk and retail products for aflatoxins, OTA and patulin[45]; no procedures are available at the primary processing level in producing countries.

ANALYTICAL METHODS

17. With regard to the control of OTA levels in cocoa products, very few methods have been published[2 7 10-12 14 32 33]

18. To detect OTA occurrence in cocoa powder products a fast efficient and sensitive analytical method is needed. Cocoa powder is a food matrix quite different from fresh fruits, cereals, coffee or wine and its extraction step optimization requires specific study[17 58].

19. An interlaboratory study[12] aimed at assessing the performances of 18 labs for OTA determination in cocoa powder samples has been described. The study concluded that a low level (0.19 ug/kg), 10/18, at median level (0.45 ug/kg), 11/18, and at high level (1.45 ug/kg), 12/18 results fell in the satisfactory ranges. The main method used was a reversed-phase HPLC protocol with clean-up by an immunoaffinity column containing antibodies specific to OTA, and quantified by fluorescence detection[11].

20. The discrepancy among the data observed in the literature may be due to differences in the analytical method of detection and quantification applied[7].

21. When a high number of samples has to be screened for OTA production, rapid, inexpensive and easy-to-perform methods are desirable, especially in low-income countries in which surveillance is less available because of economical and technological constraints[47]. Reliable results have been obtained with planar chromatography methods such as TLC and HPTLC which may be an alternative to HPLC, at least for the detection of higher quantities of OTA. Experiments with TLC showed LOD of 2.7 ug/g[18].

OCCURRENCE OF OTA IN COCOA BEANS

22. OTA contamination was found in 17.6% of 56 cocoa bean samples with levels ranging between 100-500 ug/kg. With roasted cocoa beans, 3 of the 19 samples analysed for OTA were contaminated (100 ug/kg)[40].

23. OTA levels in 16 of 21 cocoa bean samples contaminated from West Africa ranged between 0.1 – 3.5 ug/kg[7].

24. None of the 15 cocoa bean samples from Ghana analysed by Honholt[31] contained any detectable levels of OTA (LOD=0.1 ug/kg).

25. All 3 samples analyzed for OTA in the raw cocoa shells were positive for OTA at levels between 1.8 – 3.4 ug/kg[10]; similarly all 10 samples analyzed for OTA in the roasted cocoa shell ranged between 2.90 – 23.1 ug/kg[7].

26. A German study in which no cocoa bean sample exceeded 2 ug/kg has also been reported[10]; CAOBISCO/ECA/FCC[16] found that only 14% of 1220 samples were above 2ug/kg.

27. Amezqueta[2] detected OTA in 46 cocoa bean samples of different origins and batches. A total of 63% of the cocoa bean samples were contaminated with a level >LOD (0.04 ug/kg). The mean and median obtained for the cocoa beans were 1.71 and 1.12 ug/kg respectively, within an interval of 0.04 to 14.8 ug/kg.

28. Starting in 1999 European industry has analysed samples of imported cocoa beans from different origins. Fig. 1 shows that OTA contaminated cocoa beans found in all cocoa producing regions. (Statistical sampling plans were not used and all producing countries were not covered)[30].

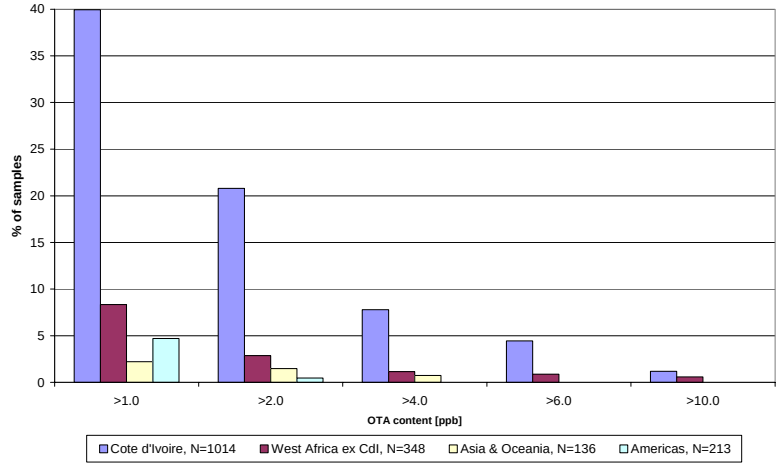

Fig. 1. OTA distribution in producing countries

29. Out of 168 cocoa bean samples analysed for OTA in the 2001/2002 cocoa season, 63 samples (38%) had levels >0.5 ug/kg, 28 samples (17%) had levels >2.0 ug/kg, and only 7 samples had levels above 10 ug/kg. OTA was not found in 48 samples (26%). OTA levels were also found to vary with the season of harvest[30].

30. Incidence of OTA during primary processing of cocoa was found to vary by the general phytosanitary conditions of the harvested pod and the climatic conditions at the time of harvesting and processing. For example, mean OTA distribution by pod phytosanitary condition was as follows: healthy (2.3 ug/kg), pest damaged (4.2 ug/kg), wounded (19.8 ug/kg), rotten (7.2 ug/kg) and mummified (3.4 ug/kg)[6]

31. Several efforts had been made to isolate and identify ochratoxin A producing moulds from cocoa beans. Out of 66 strains isolated during fermentation and drying of cocoa beans from Ghana, none was able to produce OTA. A total of 13 strains from Cote d'Ivoire, 16 strains from Nigeria and 86 strains from Ghana were screened for OTA production and only two ochratoxigenic *aspergilli* were found[18].

32. In a Brazilian study, 21 cocoa product samples (nuts, nibs, casca flocada and cocoa powder) were evaluated for OTA production capacity. Out of 123 *Aspergillus* toxigenic isolates obtained from 42.9% the cocoa samples, 18.2% *A. niger*, 100% *A. carbonarius* and 100% *A. ochraceus* were OTA producers[23].

33. Incidence of OTA in cocoa and cocoa products from various producing countries is tabulated in Annex 2.

OCCURRENCE OF OTA IN COCOA SHELLS

34. A study[2] was conducted to determine the influence of shelling on lowering OTA content in cocoa beans. The reduction was from 50 to 100% showing that the highest contamination resides in the shell.

35. OTA was analysed in 15 pairs of cocoa shell and nib samples[30]. The results showed that on average 48% (range 25-72%) of OTA in the beans was removed with the shell fraction. The calculated OTA concentration in the beans was 0.3-3.0 ug/kg

36. Using a handmade cocoa shelling process, Amezqueta[1] observed a reduction in OTA content by >95% in 14/22 samples, 65-95% in 6/22 samples and only one sample showed a reduction of less than 50%.

37. Analysis of 170 samples of cocoa products of different geographical origins indicated that highest levels of OTA were detected in cocoa shell and cocoa cake (0.1 to 23.1ug/kg) and only a minor level in the other cocoa products[7].

OCCURRENCE OF OTA IN COCOA PRODUCTS

38. In a 2005 study[42] involving 41 retail chocolates in Japan, all samples showed some level of contamination with OTA. Levels in 14/41 were below the LOQ (0.10 ug/kg), 7/41 were below 0.20 ug/kg and the rest (25/41) contained levels above 0.20 ug/kg, all in the range of <0.10 to 0.94 ug/kg.

39. Twenty six cocoa and chocolate samples were free from detectable OTA (<0.10 ug/kg) from 170 cocoa samples investigated. In roasted cocoa powder 38.7% of the samples analyzed contained OTA levels ranging from 0.1 to 2 ug/kg, and 54.8% was contaminated at >2 ug/kg[7].

40. Of 547 cocoa product samples analysed from several foods from European countries 445 were positive. The contamination level varied from 0.01 to 3.8 ug/kg, with 0.23 ug/kg average[44].

41. Tafuri[58] analysed 18 samples of cocoa in powder (sold in Italy) for OTA presence. Nine samples were below the limit of detection of 0.01 ug/kg; the other nine had the toxin from 0.22 to 0.77 ug/kg, with a mean of 0.43 ug/kg.

42. The report on the Task for Scientific Cooperation 3.2.7[44] showed that 81.3% of the cocoa-derived products analysed were contaminated with OTA.

43. A study by Burdaspal and Legarda[14] reported OTA detection in 99.7% of samples of chocolate and cocoa products analysed.

44. MAFF[41] presented data in 1997 and 1998 on cocoa powder samples which indicated that 19/20 samples analysed in 1997 contained OTA to a maximum level of 2.4 ug/kg with a mean of 0.68 ug/kg and 20/20 samples analysed in 1998 yielded a mean of 1.67 ug/kg. Out of 40 chocolate samples 30 contained less than 0.6 ug/kg.

45. CAOBISCO/ECA/FCC[30] launched a research project in 1999 "to specify as precisely as possible occurrence of OTA and the conditions favouring OTA formation in cocoa and actions believed to minimize formation". Analysis of cocoa products on the European market, under this project, confirms that only low levels of OTA are present in cocoa containing products as consumed. The mean OTA levels found in the various products were as follows (samples have been analysed by different laboratories with LODs of 0.1, 0.2, or 0.5 ug/kg):

- milk chocolate (228 samples), 0.16 ug/kg
- dark chocolate (526 samples), 0.26 ug/kg
- cocoa drink powder (247 samples), 0.20 ug/kg
- cocoa powder (1189 samples), 1.0 ug/kg

Similar results have been reported from Spain and Germany[14, 25].

46. In the study conducted in Spain[14], 296 samples of different types of chocolate and cocoa powder were analysed from Spain, thirteen European countries, Argentina and Japan, the results indicated that consumption of chocolate and cocoa products under normal conditions contributed only a minor fraction of the TDI of OTA. Tabulated below are median values of OTA found in the various cocoa products. (LOQ=0.012 ug/kg; number of samples in each category in parenthesis).

47. Table 1: Median OTA content of chocolate and cocoa products from Spain and 15 other countries.

Cocoa product	Median OTA content in Spain	Median OTA content in Foreign countries
Dark, bitter, & plain chocolate	0.246 pg/kg (35)	0.268 ug/kg (52)
Milk chocolate	0.116 pg/kg (47)	0.100 pg/kg (122)
White chocolate	0.030 pg/kg (5)	0.027 ug/kg (9)
Cocoa powder	0.242 ug/kg (21)	0.168 pg/kg (5)

48. An overview of levels of OTA encountered in various cocoa products is tabulated in Annex 3.

DIETARY INTAKE

49. Based on a mean consumption of 8.6 g of chocolate and cocoa product in Spain an OTA weekly intake of 0.252 ng/kg bw was derived[14].

50. Estimated total maximum weekly exposure of children under 6 years to OTA from chocolate and cocoa products is 3.7 ng/kg bw based on available consumption data in many European countries[16].

51. Data from a national exposure study carried out in France in 1999 showed that chocolate and cocoa products only contribute to a very small percentage of the overall OTA exposure, even for the 5% of consumers who had the highest intake of chocolate and cocoa products[16].

52. The SCOOP Task 3.2.2 presented data which indicated that the daily intake of cocoa was 31g/day/person corresponding to OTA intake of 21 ng/kg/wk/person. This report also noted that this amount of cocoa contributed 5% of total OTA intake compared to cereals which contributed the bulk of 55%. The follow up SCOOP Task 3.2.7[44] indicated that cereal was still the main contributor at 50% with cocoa at 4% of total intake.

53. To estimate the dietary exposure to OTA , the Food and Environmental Hygiene Department (FEHD)[27] of Hong Kong completed a study in February of 2006 which covered 8 major food groups including chocolate and cocoa products. Of the 287 food samples which tested for OTA, it was found that dietary exposure to OTA was 4 and 9ng/kg bw/week for the average secondary school student and above average consumer respectively. The main dietary source of OTA was cereal and cereal products (61% of total exposure), chocolates contributed 6% of the total dietary exposure.

REGULATORY STATUS

54. Before the recent EU Commission Regulation 1881/2006, at least 11 European countries have proposed or enacted regulations for OTA in various foodstuffs[8, 27, 54, 60, 61].

55. The EC has now set maximum levels, to take effect on 1 March 2007, for cereals, cereal products, dried vine fruit, roasted coffee, wine, grape juice and foods for infants and young children based on new scientific information[21, 22, 49].

56. According to a working document[62] from the Expert Committee "Agricultural Contaminants" on OTA regulation, there exist the following proposals for regulations on cocoa and cocoa products: (a) raw materials for manufacturing of foodstuffs (cocoa bean, cocoa nibs, cocoa mass, cocoa cake and cocoa powder, 2 ug/kg) and (b) consumer products (powdered chocolate, chocolate in powder, chocolate, and drinking chocolate, 1 ug/kg).

57. The US FDA has not set advisory limits or action levels for ochratoxins in any commodity.

58. The latest EU review of regulatory limits for OTA in foodstuffs noted that no limits would be set for meat (since it tends to contain only low levels of OTA), green coffee (which is not consumed in its raw form and a high percentage of OTA can be removed by roasting) and cocoa beans (which are also not eaten in their raw form and consumers would be protected by setting limits for cocoa products)[28].

PREVENTION OF OTA IN COCOA

59. The European chocolate and cocoa industry and producing countries are engaged in studies to understand sources of contamination and appropriate remedial actions.

60. The research has covered all stages from growth of cocoa to production of finished products. It has been shown that OTA can be found on beans from most producing countries and that the practice during early processing steps at the cocoa farm is critical. Therefore interventions have to be made at the farm level for a significant reduction of OTA contamination to happen[30].

61. A major part of OTA originally present in cocoa beans is found in the shell fraction, which is removed during processing. Other processing steps from cocoa beans to finished products do not lead to removal or destruction/degradation of OTA. Thus a well-controlled shelling process could achieve a very significant reduction in OTA levels in cocoa-derived products[1].

62. No quality management systems have ever been implemented in the primary processing of cocoa. Dahl[24], working under the EU-funded Cocoqual Project, has developed a Quality Management System based on ISO 22000 for the primary processing of cocoa for the purpose of ensuring good quality including prevention of OTA.

63. Other data from the Cocoqual Project[18] showed that 15 different strains of lactobacillus isolated from cocoa inhibited the growth of OTA producing strains of *Peniclilium nordicum.* This observation has profound food safety implications which could be exploited for prevention of OTA in cocoa.

64. A proposal for a methodology to reduce OTA contamination in cocoa by working with cocoa farmers has been discussed[29].

CONCLUSIONS AND RECOMMENDATIONS

65. The present Discussion Paper on OTA in Cocoa leads to the following broad conclusions and recommendations for consideration at the 39th Session of CCFAC:

(a) Cocoa production represents an important economic activity for all the cocoa producing countries in Africa, Asia and Latin America.

(b) Cocoa is a minor component of the human diet and has a small contribution to total dietary intake of OTA (4-6 % of total intake).

(c) A major part of OTA originally present in cocoa beans is found in the shell fraction, which is not consumed.

(d) Before a code of practice for OTA in cocoa is considered, it is recommended that CCFAC considers the following:

  (i) Additional data on the occurrence of OTA in cocoa is necessary to supplement those presented in this document.

  (ii) It is recommended that an international specific sampling plan for cocoa be developed.

  (iii) To minimize discrepancy in collected data the HPLC method with immunoaffinity column and detection by fluorescence be adopted for cocoa and cocoa product quantitative analysis; the HPTLC method documented in this paper be adopted for large scale screening for OTA in producing countries.

  (iv) Codex member states should be encouraged to submit data from surveys of levels of OTA in cocoa and cocoa products in their countries, using validated analytical methods, and over a period of several years to reflect seasonal variations. These data would be used in developing a code of practice.

  (v) Research on methods to prevent and/or reduce contamination of cocoa in the field, during the primary processing of cocoa should be encouraged and continued. There is need for a better understanding of the mould-cocoa interactions in symptomatic and asymptomatic infections of cocoa in the field.

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ANNEX 1

World Production of Cocoa Beans (2003 – 2006)

Country	2003/2004		2004/2005		2005/2006	
Africa	**1250**	**72.1**	**2379**	**70.3**	**2577**	**71.7**
Cameroon	162		184		168	
Cote d'Ivoire	1407		1286		1387	
Ghana	737		599		740	
Nigeria	180		200		170	
Others	64		110		112	
America	**462**	**13.1**	**443**	**13.1**	**447**	**12.4**
Brazil	163		171		162	
Ecuador	117		116		115	
Others	182		156		170	
Asia & Oceanía	**525**	**14.8**	**560**	**16.6**	**568**	**15.8**
Indonesia	430		460		470	
Others	95		100		98	
World Total	**3537**		**3382**		**3592**	

Source: ICCO Quarterly Bulletin of Cocoa Statistics.
Vol. XXXII. No. 4. Cocoa year 2005/2006

ANNEX 2

Incidence of ochratoxin A in cocoa and cocoa products from various producing countries

Origin	No. of positive/ No. of samples	Range of OTA (ug/kg)	Cocoa or cocoa product
Africa (Cote d'Ivoire, Cameroon, Guuinea, Nigeria, Senegal)	16/21	0.1 – 3.5	Cocoa bean
Africa (Cote d'Ivoire, Ghana, Nigeria); **Asia** (Indonesia, Malaysia); **Latin America** (Ecuador, Honduras, Peru)	74/80	0.1 – 9	Cocoa cake
Africa (Cote d'Ivoire, Cameroon)	4/8	0.1 – 3.5	Cocoa mass
Africa (Cote d'Ivoire, Cameroon, Nigeria)	3/3	1.8 – 3.4	Raw cocoa shell
Africa (Cote d'Ivoire, Cameroon)	10/10	2.9 – 23.1	Roasted cocoa shell
Africa (Cote d'Ivoire, Nigeria)	0/2	<0.1[a]	Roasted nibs.
Africa (Cote d'Ivoire, Cameroon)	0/4	<0.1	Cocoa butter
Africa (Cote d'Ivoire, Cameroon, Guinea, Nigeria	29/31	0.1 – 4.4	Cocoa powder
Unknown	8/11	0.1 – 1.59	Chocolate and chocolate cream
Cote d'Ivoire	24/33	0.04[a] – 14.8	Cocoa bean
Cameroon	3/7	0.04[a] – 3.88	Cocoa bean
Equitorial Guinea	29/46	0.04[a] – 0.42	Cocoa bean

[a]Corresponds to LOD of method

Data from Bonvehi (2004) and Amezqueta et al (2004)

ANNEX 3

Levels of OTA in cocoa beans and cocoa products

Product	No. of positive/ No. of samples[a]	Range of OTA (ug/kg)
Cocoa	0/15 10/56 16/21	<LOD=0.1 100-500 0.1-3.5
Roasted cocoa beans	3/19	100
Roasted cotyledon	0/2	<LOD=0.1
Raw cocoa shell	3/3	1.8-3.4
Roasted cocoa shell	10/10	2.90-23.1
Cocoa cake	74/80	0.1-9
Cocoa mass	4/8 0/1	0.1-3.5 <LOD=0.25
Cocoa butter	0/4 0/4	<LOD=0.1 <LOD=0.25
Cocoa powder	40/40 29/31 20/20 0/6 39/40 344/733 9/18	0.09-1.80 0.1-4.4 1.3-2.4 <LOD=0.25 0.2-2.4 - 0.22-0.77
Cocoa powder (commercial)	26/26 9/18 0/115	0.05-0.93 0.22-0.77 -
Ready-mixed cocoa drinks	34/34	0.005-0.054
Chocolate drinks	51/56	<0.01-0.63
Chocolate	295/352 30/40 0/8 18/40	0.01-3.6 0.1-0.6 <LOD=0.25 0.10-0.6
Dark chocolate	87/87 9/295	0.02-4.29 -
Milk chocolate	169/169	0.02-0.70
White chocolate	13/14 1/119	0.02-0.19 -
Chocolate and chocolate cream	8/11	0.1-1.59

[a]Source: cited from Dahl (2006): Data from Honholt (2003), Krogh (1987), Bonvehi (2004), Brera et al (2003), Tafuri et al (2004)