CODEX ALIMENTARIUS COMMISSION E

Food and Agriculture Organization of the United Nations

World Health Organization

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Agenda Item 6 **CX/CF 15/9/6**

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CODEX COMMITTEE ON CONTAMINANTS IN FOODS

9th Session
New Delhi, India, 16 – 20 March 2015

PROPOSED DRAFT MAXIMUM LEVELS FOR CADMIUM IN CHOCOLATE AND COCOA-DERIVED PRODUCTS

(Prepared by the Electronic Working Group led by Ecuador and co-chaired by Ghana and Brazil)

Codex Members and Observers wishing to submit comments at Step 3 on the proposed draft MLs for cadmium in chocolate and cocoa-derived products, including possible implications for their economic interests, should do so in conformity with the *Uniform Procedure for the Elaboration of Codex Standards and Related Texts* (Codex Alimentarius Commission Procedural Manual) before **31 January 2015**. Comments should be directed:

to:	with a copy to:
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Note: Data and information in support of the conclusions and recommendations are presented in the Annex and are not subject to comments. The conclusions and recommendations are for consideration by Codex members, international observer organizations and the Committee. The proposed MLs are for comments at Step 3 by Codex members and international observer organizations and for consideration by the Committee.

BACKGROUND

1. The 6th Session of the Committee on Contaminants in Foods (2012) was informed that a proposal for exposure assessment of cadmium from cocoa and cocoa products was made for inclusion in the priority list of contaminants and naturally occurring toxicants proposed for evaluation by JECFA. The Committee agreed to include the proposal in the list and noted that relevant data would be needed to undertake the assessment.[1]

2. Following the request of the 6th CCCF, the issue of exposure assessment to cadmium from cocoa and cocoa products was considered by the 77th JECFA (2013).[2] The outcome of the JECFA meeting was considered by the 8th CCCF (2014).

[1] REP12/CF, paras 159 and 161, Appendix XI.
[2] The full report of the 77th JECFA meeting is available at http://apps.who.int/iris/bitstream/10665/98388/1/9789241209830_eng.pdf

3. The 8th Session of the Committee agreed to initiate new work on MLs for cadmium in chocolate and cocoa-derived products. The Committee agreed to establish an electronic working group led by Ecuador, co-chaired by Ghana and Brazil[3] to prepare proposals for MLs for comments at Step 3 and consideration at the next session of the Committee.[4]

4. The 37th Session of the Codex Alimentarius Commission (2014) approved new work on maximum levels for cadmium in chocolate and cocoa-derived products as proposed by CCCF.[5]

5. The objective of the new work is therefore to provide harmonized MLs for cadmium in chocolate and cocoa-derived products to protect the health of consumers and ensuring fair practices in the food trade.

6. Based on data and information provided in the Annex, the following conclusions and recommendations are for consideration and comments by Codex members and observer international organizations.

7. Codex members and international observer organizations are invited to consider the conclusions and recommendations and provide their comments on the proposed MLs for consideration by the 9th CCCF as follows.

CONCLUSIONS

For consideration when commenting on the proposed draft MLs

1. In the food industry there are various cocoa products containing different content of cocoa solids, such as chocolate bars, cocoa powder, biscuits, ice cream, chocolates, etc. Chocolate is a clear example of that.
2. On the world market there are products containing from 20% to 90% of cocoa solids. Additionally, studies presented in this investigation suggest that there is a direct relationship between the solids and traces of heavy metals in chocolate (Yanus, *et al*. 2013).
3. The absorption of cadmium in humans is low, approximately 6% in people with iron deficiency up to 9% (ATSDR, 2008).
4. Another aspect to consider when setting Maximum Levels is the percentage of cadmium absorption in humans. In general, the digestive system of children and adolescents can absorb cadmium easier than an adult (Yanus, *et al*. 2013), so that the susceptibility of adverse effects in these groups is higher compared to adults (Jalbani et al, 2009).
5. This statement leads to setting lower limits on children's favorite products (chocolates with solid content <50%).
6. Globally, many countries have not established ML for Cd for products derived from cacao and there is only a limited number of countries that have presented any type of study to determine the content of this metal in chocolate and derived products. This situation has led to the limits established by many countries, not supported on a scientific basis, which could affect the international trade of this product.
7. Studies from several countries, as detailed herein, are varied. For example, Canada, for a chocolate with more than 50% of cocoa solids with a range of LOD of 0.02 to 0.86mg/kg, with an average of 0.17mg/kg; for cocoa powder to a LOD of 0.02 to 1.25mg/kg with an average of 0.34mg/kg; in the case of the Ecuadorian chocolate over 50% of cocoa solids, the range goes from 0.03 to 1.56 with an average LOD of 0.378mg/kg and a chocolate containing dry material less than 50% has a LOD range of 0.02 to 0.12mg/kg with an average of 0.062mg/kg; in the case of MERCOSUR for a chocolate and cocoa products with less than 40% of cocoa has a recommended limit of 0.2mg/g. As can be seen, these investigations show dispersed cadmium concentrations.
8. JECFA at its 77th Session estimated that the dietary exposure to cadmium from the average population for products containing cocoa and its derivatives is in the range from 0.005 to 0.39mg/kg bw per month, which is 0.02 to 1.6% of the provisional tolerable monthly intake (PTMI) of 25mg/kg bw per month.
9. The estimation of JECFA can be demonstrated as follows: if PTMI is 25mg/kg bw, i.e. 0.025mg/kg, an adult of average weight (70kg) should consume about 44 chocolate bars of 20g to exceed the provisional tolerable monthly intake of cocoa products.

[3] The list of participants will be included when available. However, as the list does not impact on the content, the paper is distributed without the list to facilitate submission of comments in time for consideration by the 9th CCCF.
[4] REP14/CF, paras 141-142, Appendix XI
[5] REP14/CAC, Appendix VI

10. Finally, the establishment of ML must consider not only the effect on the health of primordial way but also the commercial component and its effects on developing economies particularly. The multilateral rules provide in several provisions the right of countries to establish SPS to protect people life, on a scientific basis and minimize the negative effects on trade measures.

11. Based on the foregoing, we conclude that to establish ML for cadmium in these products should be considered the cocoa solids present, as well as, the absorption of this metal in different age groups of humans.

RECOMMENDATIONS

For consideration when commenting on the proposed draft MLs

1. By the conclusions outlined in this document, the following table shows values of ML for cadmium in chocolate and cocoa derived products to protect the health of the consumers and ensure fair practices in the food trade.

2. Once available information was gathered and analyzed, the eWG would like to recommend taking into consideration the ML described in the table, because it summarizes the different studies performed by several countries and international organizations on the content of cadmium in chocolate and cocoa derived products, as well as the exposure in the human diet. However, the analysis of this information suggests that it is necessary to conduct studies on this area such as:

3. Influence of the amount of cocoa solids in the concentration of cadmium in cacao.

4. A study to determine the content for cadmium in the ingredients that chocolate and cocoa derived products are elaborated with, such as sugar, milk, etc.

PROPOSALS FOR MAXIMUM LEVELS FOR CADMIUM IN CHOCOLATE AND COCOA-DERIVED PRODUCTS FOR COMMENTS AT STEP 3

Products	Cadmium Maximum Level (mg/kg)
1. Milk Chocolate with <30% total dry cocoa solids	0.20
2. Chocolate with <50% total dry cocoa solid; Milk Chocolate with ≥30% total dry cocoa solids.	0.60
3. Chocolate with ≥50% total dry cocoa solids.	2.00
4. Cocoa powder sold to the final consumer or as an ingredient in sweetened cocoa powder sold to the final consumer (beverageing chocolate)	1.50

ANNEX

BACKGROUND INFORMATION ON THE DEVELOPMENT OF THE PROPOSED MAXIMUM LEVELS FOR CADMIUM IN CHOCOLATE AND COCOA-DERIVED PRODUCTS

BACKGROUND

1. Contamination of heavy metals in the human diet has become a topic of concern in many countries around the world, for its high concentration may cause health problems in humans.

2. Cadmium is abundant in nature and can be released to the environment in different number of ways, including natural activities such as volcanic activity (WHO, 2010). The consequences of the contamination caused by cadmium in chocolate and cocoa products are an issue of commercial interest that impacts the economy of producing countries (ICCO, 2012). The evaluation by JECFA (77th Session) stressed that the total exposure of cadmium in diets with high levels of consumption of cocoa and cocoa products was apparently overestimated and not considered to be of concern, however, lack the establishment of a Maximum level (ML) of cadmium for chocolate and cocoa products could threaten exports of some countries, especially, developing countries, who are the largest exporters of cocoa.

3. Cocoa producers worldwide were alarmed when the EU announced plans to implement regulations for chocolate and cocoa products containing certain levels of cadmium (Cd).The decision by the European Union was the result of a report on the cadmium content in chocolate, prepared by the European Food Safety Authority (EFSA) of 23 January 2012 whereby the European Union recommended that chocolate with a greater than or equal to 50% cocoa solids amount should contain a maximum of 0.3mg/kg Cd.

4. Considering that it is necessary to have wider scientific and technical assessments, both in producing countries and importing cocoa, this document proposes to establish ML cadmium in chocolate and cocoa products through the Committee on Contaminants in Foods (CCCF), with the aim of harmonizing international trade.

INTRODUCTION

ECONOMIC IMPORTANCE OF COCOA WORLDWIDE

5. The expression “cocoa” is derived from the plant Theobroma cocoa L., which belongs to the family Malvaceae. The tree is native to the Amazon.

6. Cocoa is a valuable cash crop, nonperishable and generally produced by small farmers who drive economies of developing countries. According to the International Cocoa Organization (ICCO), the cocoa growing areas are, according to their importance, West Africa, Southeast Asia and Latin America. About 72% of the world supply of cocoa beans comes from West Africa, especially Côte d’Ivoire, Ghana and Nigeria (Table 1).

Table 1. World production of cocoa beans (2012 - 2014)

	Thousands of tons					
COUNTRY	**2011-2012**		**Estimated (2012-2013)**		**Estimated (2013-2014)**	
AFRICA	**2920**	71.4%	**2820**	71.5%	**2942**	71.7%
Cameroon	207		225		210	
Côte d’Ivoire	1486		1449		1550	
Ghana	879		835		870	
Nigeria	235		225		220	
Others	113		86		92	

	Thousands of tons					
COUNTRY	**2011-2012**		**Estimated (2012-2013)**		**Estimated (2013-2014)**	
AMERICA	**655**	16.0%	**626**	15.9%	**666**	16.2%
Brazil	220		185		200	
Ecuador	198		192		210	
Others	237		249		256	
ASIA AND OCEANIA	**512**	12.5%	**496**	12.6%	**496**	12.1%
Indonesia	440		420		410	
Papua New Guinea	39		36		40	
Others	33		40		46	
WORLD TOTAL	***4087***	100%	**3942**	100%	**4104**	100%

Note: Totals may differ from the addition of components due to rounding.

Source: Quarterly Bulletin of Cocoa Statistics, Vol. XI, No.1, Cocoa Year 2013/2014. Published: 28-02-2014. Elaboration: International Cocoa Organization (ICCO)

7. Europe demands most of the milled cocoa beans (Table 2) for the production of cocoa liquor, cocoa butter and cocoa powder. These beans will be processed into cocoa powder and chocolate (ICCO, 2007). European countries represent about 58% of net imports of cocoa, followed by North America (27%), Asia (14%) and Africa (2%). The United States is the largest importer worldwide, representing 20% of net total imports, followed by Germany (13%), Belgium (7%) and France and the Russian Federation (6% each one). Europe is by far, the largest importer of cocoa beans and the vast majority of imports of cocoa come from West Africa (93%). Imports from Latin America and South - East of Asia have a secondary and tertiary importance, respectively (ICCO, 2012).

Table 2. World Consumption / Milled cocoa beans

	Thousands of tons					
COUNTRY	**2011-2012**		**Estimated (2012-2013)**		**Estimated (2013-2014)**	
EUROPE	**1521**	38.4%	**1581**	38.8%	**1620**	38.8%
Germany	407		400		418	
The Netherlands	500		535		545	
Others	614		646		657	
AFRICA	**717**	18.1%	**769**	18.9%	**797**	19.1%
Côte d'Ivoire	431		471		500	
Ghana	212		225		230	
Others	74		73		67	

	Thousands of tons					
COUNTRY	**2011-2012**		**Estimated (2012-2013)**		**Estimated (2013-2014)**	
AMERICA	**845**	21.4%	**881**	21.6%	**889**	21.3%
Brazil	242		241		240	
United States	387		412		415	
Others	216		228		234	
ASIA AND OCEANIA	**874**	22.1%	**846**	20.8%	**872**	20.9%
Indonesia	270		255		275	
Malaysia	297		293		290	
Others	307		298		307	
WORLD TOTAL	**3957**	100%	**4077**	100%	**4178**	100%
MILL ORIGIN	**1728**	43.7%	**1759**	43.1%	**1810**	43.3%

Note: Totals may differ from the addition of components due to rounding.

Source: Quarterly Bulletin of Cocoa Statistics, Vol. XI, No.1, Cocoa Year 2013/2014. Published: 28-02-2014. Elaboration:

International Cocoa Organization (ICCO)

8. According to data from Trade Map (2013), global imports of cocoa whole grain or broken, raw or roasted were 63.73%, cocoa paste - cacao liquor was 1.93%, butter, fat and oil of 18.60% due cocoa and cocoa powder, not containing added sugar or other sweetening matter was 15.74%.

9. The cocoa bean market in the world is distinguished by two categories: 1) the “fine flavour” cocoa and 2) “basic cocoa” or “ordinary cocoa”. According to the ICCO, the global share of fine flavour cocoa is about 5-7%, representing 100 000 - 170 000 tons from Ecuador, Indonesia, Papua New Guinea, Colombia, Venezuela, Trinidad and Tobago, among others. On the other hand “basic cocoa” or “ordinary cocoa” which comes from Africa, Asia, Central and South America represents around 95-93% of the world production (ICCO, 2012).

10. The characteristics of the “fine flavour” cocoa are distinctive for its aroma and flavour, which are mainly demanded by manufacturers of fine chocolates. Traditional consumers of this type of cocoa are Western Europe (Belgium, Luxembourg, The Netherlands, France, Germany, Italy, Switzerland and the UK), who represent the largest consumer markets. Products made from these grains are first -origin quality products only high percentage of cocao mostly consumed by adults, who are willing to pay higher prices.

11. The public authorities, including the European Food Safety Authority and the Food Advisory Committee (United States of America) have conducted research on flavonoids in cocoa and chocolate products and have found that cocoa flavonoids are associated with a lower risk cardiovascular disease and contributes to the maintenance of vasodilatation endothelium-dependent, so the demand for cocoa products is constantly growing (EFSA, 2012).

12. Latin American countries are major contributors in cocoa production. There are 500 000 cocoa farmers in the region, with over 3.5 million small farmers worldwide, for which cocoa production is based on the family finances. Of the countries that produce fine cocoa aroma, Ecuador, Peru, Colombia and Papua New Guinea are the largest suppliers to Europe.

TOXICOLOGICAL EVALUATION

13. Cadmium is accumulated primarily in the kidneys, and its biological half life time in humans is 10-35 years. This accumulation may lead to renal tubular dysfunction, which results in a increase of the excretion of low molecular weight proteins in urine. This is generally irreversible. A high intake of cadmium can lead to distortion in calcium metabolism and the formation of kidney stones. Cadmium also affects the skeletal and respiratory system (WHO, 2010).

14. Cadmium was assessed in Sessions 16, 33, 41, 55, 61, 64 and 73 of JECFA. In Sessions 61 and 64, the Committee noted that the cadmium estimated total mean population dietary exposure in all foods derived from per capita data from five GEMS (Global Environmental Monitoring System)/food of regional diets, ranged from 40% to 60% of the provisional tolerable weekly intake (PTWI) applicable at the moment, 7µg/kg bw. The 7 product groups that contributed significantly to the total cadmium dietary exposure were rice, wheat, vegetables with roots, tubers, leafy vegetables, other vegetables and shellfish (40-85% of total cadmium dietary exposure through five regional diets).

15. In the 73rd JECFA Meeting, the Committee revaluated cadmium and established a provisional tolerable monthly intake (PTMI) of 25µg/kg bw, reflecting the long cadmium half-life in humans. Estimations of the mean cadmium dietary exposure in all foods reported from national estimations for adults ranged from 2.2 to 12µg/kg bw per month, or 9-48% of PMTI; for European children up to age of 12, the mean cadmium dietary exposure was 11.9µg/kg bw per month (47% PMTI). The high percentile of the dietary exposure to cadmium in adults was reported in the range of 6.9 to 12.1µg/kg bw per month (28-48% of PMTI), and for children from 0.5-12 years, from 20.4 to 22.0µg/kg bw per month (82-88% of PMTI). Data about the presence of cadmium and consumption of foods containing cocoa and its derivatives were included in these estimations (JECFA, 2013).

16. Estimations of JECFA for the diet of the average population to the cadmium exposure in products containing cocoa and its derivatives for the 17 GEMS/Food Dietary Groups ranged from 0.005 to 0.39µg/kg bw per month, equivalent to 0.02% to 1.6% of tolerance. This represents an estimation of the mean cadmium dietary exposure to cocoa and its derivatives for the population. Food cadmium potential for large consumers of products containing cocoa and cocoa and other foods containing cadmium exposure were estimated between 30 to 69% of PMTCT for adults and 96% for children aged 0.5 to 12 years age. The Committee noted that this total cadmium dietary exposure to large consumers of cocoa and cocoa products was probably overestimated and did not consider it a concern (JECFA, 2013)

17. According to the evaluations of the Department of Health and Human Services (DHHS) of the United States and the International Agency for Research on Cancer (IARC, 2012), there is sufficient evidence in humans and animals about the carcinogenic property of cadmium and compounds of this metal, for people that have been exposed by their work conditions.

METHODS OF ANALYSIS

18. Methods of analysis to determine Cadmium in cocoa include Flame Atomic Absorption Spectrometry (F-AAS), Graphite Furnace with Atomic Absorption Spectrometry (GF-AAS), Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS). The general sample preparation can be conducted by digestion in an open system (dry ashing - Lee&Low, 1985 - or wet digestion - Yanus et al, 2004) or in a closed system (microwave - Nardi et al, 2009, Jalbani et al, 2009) which is the most used method in several laboratories and research. The use of hydrogen peroxide is recommended because cocoa and cocoa products are samples rich in fat. Sample preparation in an open system like dry incineration is interesting in low sensitivity techniques, however, contamination in these procedures is very common.

19. CODEX STAN 228-2001 - General Methods of Analysis for Contaminants suggests some cadmium analysis methods such as atomic absorption spectrometry (AAS) after incineration or microwave digestion (most recommended) and Redissolution Anodic voltammetry.

20. Table 3 presents the Cadmium ODL (optimal detection limit) of different analysis methods mentioned above.

Table 3. Detection limits with different methods

Technique	Detection limits (µg/l)
F AAS	0.8 – 1.5
ICP OES	0.1 – 1.0
GF AAS	0.002 – 0.02
ICP-MS	0.00001 – 0.001

Source: EFSA, 2009

21. Although there is the European Normative EN 15763-2009 which describes a method for the arsenic determination, cadmium, mercury and lead in food products by plasma induction (ICP.MS), the European Union does not recommend a specific method for cadmium determination in cocoa, laboratories may select any valid method of analysis, however, the method selected must satisfy the performance criteria described in Table 4.

Table 4. Performance criteria for analysis methods on Cadmium

Parameters	Values less than one tenth of the maximum level
LOD	Less than one tenth of the maximum level
LOQ	Less than a fifth of the maximum level
Precision	HORRATr or HORRATR values less than 2
Recovery	In case that the step of not extraction is applied in the analytical method (for example in the case of metals), the result may be reported incorrectly for recovery if provided evidence for the ideal use of certified reference material, if certified allowable concentration for the uncertainty measure is achieved (for example, high accuracy of measure). In case the result is reported incorrectly for recovery, this should be mentioned.
Specificity	Free of spectral interferences matrix

22. According to the Procedural Manual of the Codex Alimentarius Commission, the performance criteria required for maximum levels over 0.1mg/kg are the same as those established in the EU regulation for detection limit (DL), limit of quantification (LOQ) and precision. The recovery should have a range of 80% to 110%.

COCOA PROCESSING

23. The plant produces cocoa pods containing about 40 cocoa beans after harvest which is the part to extract these cocoa beans inside, separating the placenta. At this point begins the post- harvest process or otherwise known as “benefit” which consists of 2 processes, fermentation and drying (Freire, 2010).

24. There are different methods for producing fermentation and drying in producing-countries, according to their needs. Cocoa fermentation begins immediately after the beans embedded in the mucilaginous pulp (‘baba’) are separated from the placenta. The cocoa beans are subjected to microbial fermentation, allowing the development of chemical precursors in fermented grains that produce particular flavours and aromas of cocoa. (Freire, 2010).

25. After fermentation, a process that lasts from 5 to 6 days, the beans are immediately dried to prevent over fermentation, which may lead to deterioration of the product. Sun drying is usually performed or hot air drying technique is used. Small producers prefer sun drying while in large plantations the (artificial) hot air drying technique method is preferred (Hii *et al*., 2009). Drying is usually completed when the dried beans reach moisture of 7.0% (wet base).

26. Drying is a simple process but must be controlled as it should be gradually dried, so the flavours and smells are consolidated into the kernel, and the bean is ready to be stored without risk of damage by fungi or moisture.

27. As soon as the grains arrive at the factory, the grains are cleaned to ensure that they have no impurities present; the next step is to take the cocoa through a hot air chamber which raises the temperature to 80°C making the cocoa bean swell. Then these grains pass to a cold chamber, which drops the temperature dramatically causing the grain to contract so that the skin is loose. Subsequently, the grains go to a machine that divides them into small fragments, which are called “cocoa nibs” (Freire, 2010).

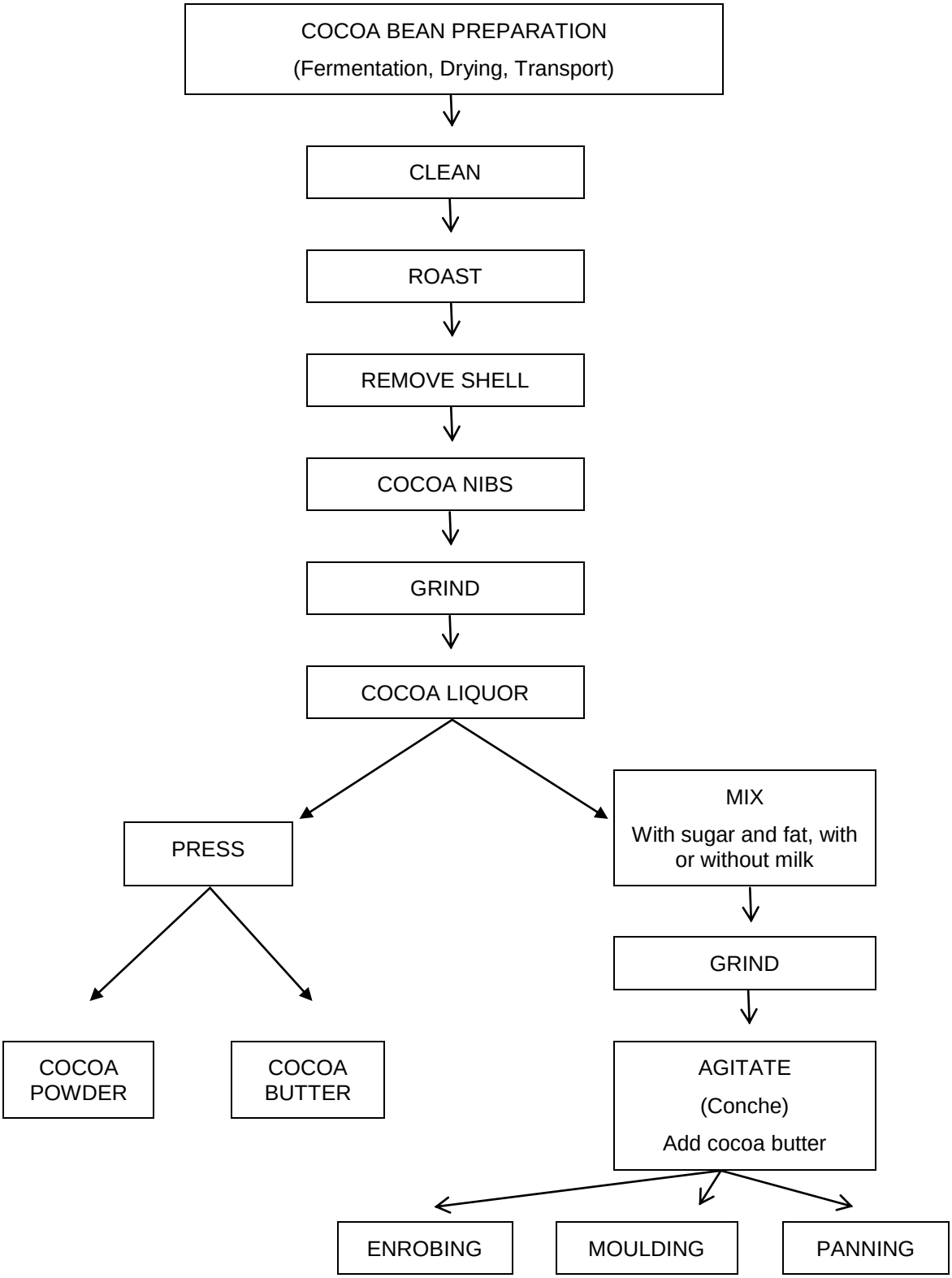
28. “Cocoa nibs” are roasted at different temperatures according to the formula, then are taken to the grinding processes, obtaining the first by-product known as “Cocoa Liquor,” which is the raw material of all derivatives of cocoa (Freire, 2010).

29. After the cocoa liquor is placed in the press, the same applies pressure exceeding 10,000kgf/cm2, obtaining two products: cocoa butter and cocoa cake. From cocoa cake, cocoa powder is obtained. (Freire, 2010)

30. The uses the products mentioned above are detailed as follows:

    - *Cocoa liquor:* raw material to obtain chocolate, cocoa butter, cocoa cake or powder material.
    - *Cocoa butter:* raw material used in the cosmetic, pharmaceutical and food industry.
    - *Powder or cocoa cake:* raw material for chocolate flavoured beverages, chocolates, biscuits and chocolate bonbon of low quality.

Figure 1. Schematic diagram of the chocolate manufacturing process.



Source: Adapted by Beckett (2008)

CADMIUM OCCURRENCE IN COCOA AND COCOA PRODUCTS

31. Cadmium is a heavy metal (atomic number 48, relative atomic mass, 112.41) which occurs naturally in the earth's crust and ocean water. Cadmium is emitted to the environment as a result of both natural and anthropogenic activities. Natural sources of cadmium include volcanic activity, erosion of rocks containing cadmium, sea foam, and mobilization of cadmium deposited in soils, sediments, landfills, etc. Anthropogenic sources of cadmium include mining and smelting of ores containing zinc, burning fossil fuels, incineration of waste and emissions from discarded batteries or municipal landfills. (ATSDR, 2008).

32. These sources contribute to the levels of cadmium in the soil and sediments. The dry or wet converter of atmospheric cadmium in plants and soil can lead to cadmium entering the food chain through foliar or root uptake. The cadmium transfer rate depends on a variety of factors, including deposition rates, type of soil and the plant, soil pH, humus content, availability of the organic matter, soil treatment with fertilizers, meteorology, and the presence of other elements such as zinc. (WHO, 2000; PNUMA, 2008).

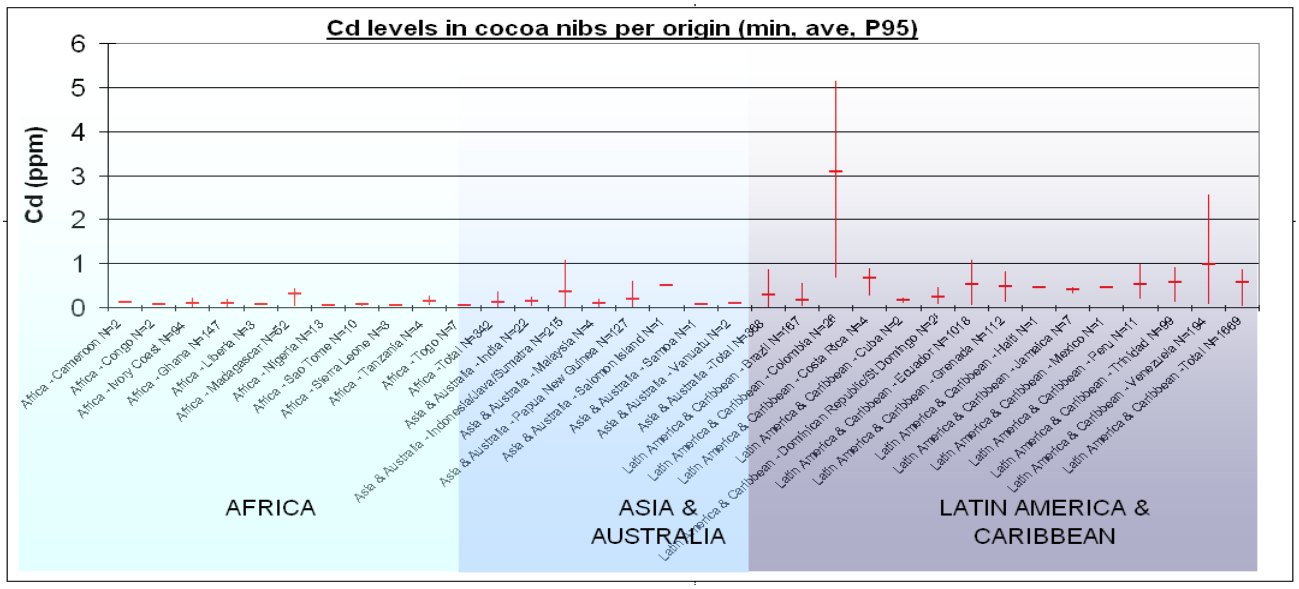
33. According to the research of Huamani - Yupanqui *et al.* (2012), they conclude that the soil type has significant influence on the absorption of cadmium by the cocoa plant. In this study, was performed a Pearson correlation analysis between available cadmium in the soil with some foliar variables, in which was found a significant and positive correlation ($P<0.05$) between total cadmium in leaf tissue and soil. On the contrary, the correlation between cadmium in the soil and the content of calcium and magnesium was significant but negative. Cadmium absorption at root level is in direct competition with other nutrients such as Calcium, Potassium, Magnesium, Iron, Copper, Manganese, Zinc, because they can be absorbed by the same protein carriers (Benavides et al. 2005, Rodríguez-Serrano *et al*, 2008).

34. For more than a decade, the Agricultural Research Institute of Ecuador (INIAP) has been investigating the presence of heavy metals in agricultural soils, waters and export crops, particularly cocoa. This study involves thousands of samples of soil, cocoa plant tissues and water. In this regard, it has been determined that the accumulation sequence of this element in the tissues of cocoa is given in the following order: root, stem, leaves, peel or seed coat and almond. This means that the cocoa almond contains the lowest percentage of cadmium compared to other tissues of the plant (Mite, 2013).

35. Cadmium levels in cocoa beans, Figure 2 can vary considerably between regions, countries and even between areas within a country. The area of lower concentration of cadmium in cocoa is West Africa; however, cocoa beans from other regions, such as South America, have inherently higher levels of cadmium. High levels of cadmium in these countries are probably due to the presence of cadmium in the soil, the use of fertilizers and other industrial activities (i.e. mining extraction) or environmental pollution (CAOBISCO/ECA, 2011).

Figure 2. Data of cadmium presence in the tips or cocoa nibs of different origins

Source: CAOBISCO/ECA, 2011



Source: CAOBISCO/ECA, 2011

STUDIES ON CONTENT OF CADMIUM IN CHOCOLATE AND COCOA PRODUCTS OF DIFFERENT ORIGINS

36. Because of the concern about cadmium contamination in cocoa and cocoa products reached international dimensions, several exporting countries and consumers conducted several studies to determine the presence of this metal in such products.

37. A study of cocoa beans obtained from various plantations in Nigeria display data in which cadmium residues in cocoa beans are probably small because of the low contamination of agricultural soils (Aikpokpodion *et al.,* 2013). However, a study of cadmium in cocoa beans obtained from Peru and Venezuela shows high levels (Figure 3 and Figure 4).

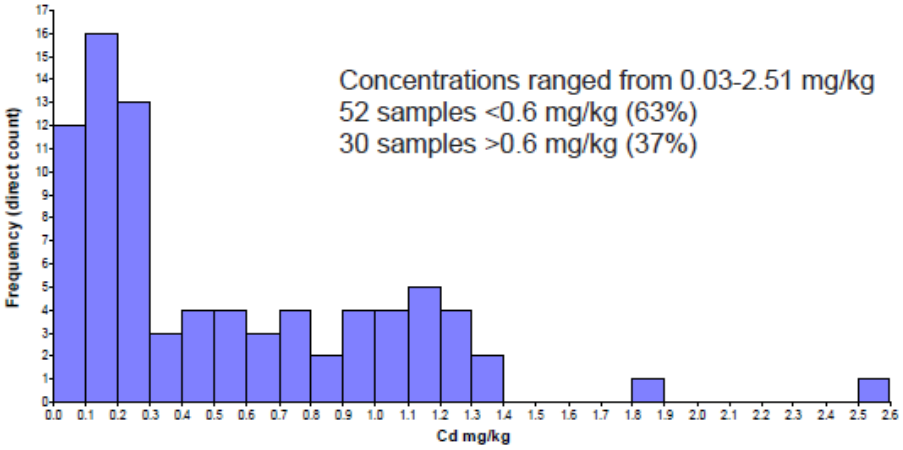


Figure 3. Concentration of cadmium in cocoa beans from Peru (82 samples)

Source: www.icco.org/sites/sps/documents/Cadmium%20Workshop/CABI.pdf

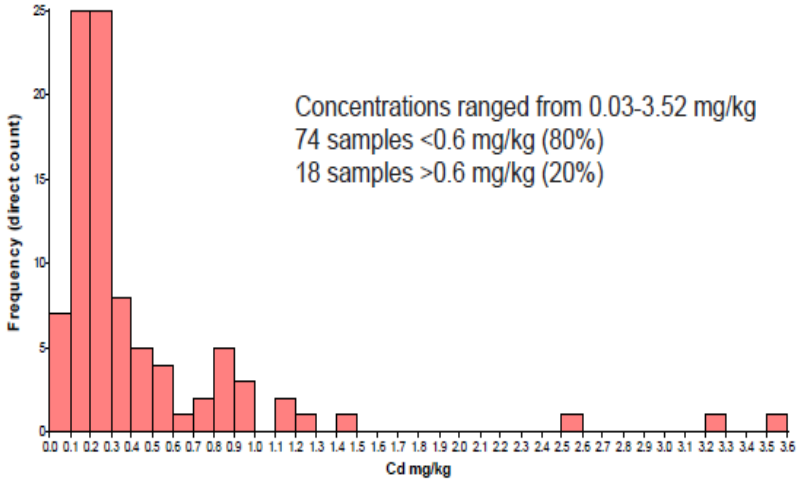


Figure 4. Concentration of cadmium in cocoa beans from Venezuela (92 samples)

Source: www.icco.org/sites/sps/documents/Cadmium%20Workshop/CABI.pdf

38. In another study in cocoa beans performed in Dominican Republic by the Food Safety Department of the Ministry of Agriculture (n=17), assessed by the Central Veterinary Laboratory, using the technique of atomic absorption spectroscopy (AAS) and replicated in the laboratory Dr. Specht of Germany (mass spectrometry with inductively coupled plasma power (ICP-MS) show cadmium levels below from those proposed by the EU Commission (0.3-0.5mg/kg), with an average result from 0.24 to 0.41mg/kg respectively (Food Safety Dept. RD, 2013).

39. In the case of Canada cadmium levels in chocolate ≥ 50% cocoa solids (n=104) and a range LOD 0.002mg/kg to 0.86mg/kg Cd with a range of 0.17mg/kg; chocolate <50% and >30% of cocoa solids with n=205 in a range of 0.01mg/kg to 0.58mg/kg Cd averaging 0.09mg/kg. Chocolate with less than 30% of cocoa solids (n=169) with a LOD range of 0.002mg/kg to 0.9mg/kg Cd averaging 0.024mg/kg and in cocoa powder (n=82) with a range of 0.02mg/kg to 1.26mg/kg Cd with an average of 0.34mg/kg. Detectable levels for cadmium were found from 98 to 100% of the samples. The averages were calculated using samples with detectable levels only for cadmium.
40. In Ghana, cadmium found in cocoa nibs (n=67) and shells (n=67) were respectively 0.269 and 0.306mg/kg in the range of 0.050 and 0.675mg/kg (nibs) and 0.050 and 0.750mg/kg (shells).
41. In the case of Ecuador, during the period 2011-2012 was conducted a study with 144 samples of chocolate bars made with cocoa from different backgrounds and marketed worldwide to analyze cadmium levels are. The analysis method used was ICP-MS. The concentration of cocoa solids in these samples ranged between 40% to 100%, with an average of 69.59%, and that for a chocolate containing cocoa total dry ≥50% (n=133) and a range of 0.03 to 1.56mg/kg Cd and an average of 0.38mg/kg Cd and in the case of a chocolate with a total dry matter content of >50% and <30% (n=11) and a range of 0.02 to 0.12mg/kg Cd and averaged 0.06mg/kg (Amores, 2012).
42. When analyzing the samples generally, the following were the results: 72% of the samples recorded contents equal to or less than 0.5mg/kg cadmium; 81% of samples showed chocolate bars cadmium content equal or less than 0.6mg/kg; 84% of the samples indicated cadmium content equal to or less than 0.7mg/kg cadmium, and 90% of cases showed cadmium content equal to or less than 0.8mg/kg. Additionally, cadmium concentrations were determined equal or more than 1mg/kg Cd, which constituted 3% of the analyzed samples (Amores, 2012).
43. In India, Dahiya *et al.* (2005) found levels of cadmium of 0.244mg/kg with a range of 0.010 to 2.730 (n=23) for cocoa-based chocolates, 0.071mg/kg range from 0.10 to 0.852mg/kg (n=22) for milk-based chocolates and 0.005mg/kg with a range of 0.001 to 0.027mg/kg (n=24) for sugar based candies. In Pakistan, Jalbani *et al.* (2009) found levels of cadmium of 0.353 ± 0.025mg/kg for cocoa based chocolates (n=20), 0.132 ± 0.012mg/kg for milk based chocolates (n=12) and 0.099 ± 0.0051mg/kg of sugar-based candies (n=8). Similar results were found in chocolates from Malaysia (Lee & Low, 1985). According to Yanus *et al.* (2014), the concentration of cadmium in chocolate from 4 different brands sold in Europe, USA and Israel ranged from 0.065 to 0.141mg/kg.
44. JECFA at its 77th Meeting, received data about the occurrence of cadmium in cocoa and cocoa products, from 13 countries (Australia, Czech Republic, Denmark, Ecuador, Estonia, France, Germany, New Zealand, Romania, Singapore, Slovakia, Sweden and USA). In total, 3919 individual samples collected from 2002 to 2011 were analyzed; the majority of them were reported in the products available in the European region. Data from the aggregate mean and median of cadmium were submitted from Australia, Ecuador, Singapore and New Zealand, with information of the sample size, but these were not used in the dietary exposure assessment.
45. The Committee classified the submitted data using five GEMS/Food identifiers: cocoa bean, cocoa powder, cocoa mass, cocoa beverage and other cocoa products (including chocolate). 50% of the samples were from other cocoa products, and 33% were for cocoa powder. The occurrence data are summarized in Table 5 (JECFA, 2013).

Table 5. Summary of cadmium occurrence data for cocoa and cocoa products

Cocoa product	N (total)	Minimum Concentration (µg//kg)	Maximum Concentration (µg/kg)	N > 100µg/kg (%)	N > 300µg/kg (%)	N > 500µg/kg (%)	N > 1000µg/kg (%)
Cocoa bean	451	ND	5239	392 (86.9%)	324 (71.8%)	245 (54.3%)	119 (26.4%)
Cocoa beverage	137	ND	290	13 (0.0%)	0	0	0
Cocoa mass	85	15	593.8	36 (37.9%)	6 (6.3%)	4 (4.2%)	0
Cocoa powder	1292	ND	1910	669 (47.4%)	55 (3.9%)	21 (1.5%)	6 (0.5%)
Other cocoa products (including chocolate)	1954	ND	1073	408 (20.8%)	78 (4.0%)	7 (0.4%)	1 (0.05%)

ND, not detected

46. JECFA evaluation used 451 samples from around the world and showed that 26.4% of the samples contained more than 1mg/kg Cd and 54.3% of the samples had values above 0.50mg/kg Cd.

47. Since cadmium is associated with the free fat cocoa solid, cadmium concentration is up to twice higher in cocoa powder than in cocoa butter and therefore higher limits are necessary in cocoa powder than in chocolate where fat free cocoa solids are diluted fat with cocoa butter, sugar and other ingredients.

48. Cadmium content in chocolate is directly related with the percentage of cocoa mass or cocoa liquor and cocoa powder. The level of cadmium in cocoa mass is the same as the cadmium content in the bean, the cadmium content in cocoa bean can be used to calculate the cadmium content in chocolate:

    - In a premium chocolate from a single source with a cocoa mass of 70%, cadmium content would be >0.5mg/kg, if the level in the beans is >0.75mg/kg.

    - This would mean that for some origin countries, the majority of the lots of cocoa beans are not acceptable for use in chocolate with a mass of origin, commonly called “origin” chocolate (100% cocoa mass from a single source).

49. With regard to cocoa powder, fine flavour beans from South America, usually are not used for the production of cocoa powder. The analytical data in Table 6 support the fact that used in the European Union cocoa powder is manufactured from cocoa beans from West Africa or from other sources not associated with high levels of cadmium.

Table 6. Reported cadmium levels in cocoa powder

	CAOBISCO	**EFSA**
Number of samples	109	389
Mean Cd (mg/kg)	0.19	0.14
P90 Cd (mg/kg)	0.37	0.20
P95 Cd (mg/kg)	0.48	0.27
Max Cd (mg/kg)	0.65	1.35

50. South American cocoa beans are rarely used in the production of milk chocolate which is normally consumed by children. These cocoa beans are used to produce premium chocolate with a high cocoa solids (dark), which are typically consumed by adults and not in large quantities due to its strong flavor and its price (this chocolate is up 10 times more expensive than the average of a milk chocolate bar) (CAOBISCO / ECCA, 2011).

DIETARY INTAKE

51. JECFA decided to use the summary occurrence data for cocoa mass as shown in Table 7, to a better representation of the products which contains cocoa and its derivatives at the raw material level for the international estimated dietary exposure since cocoa beverages, cocoa powder and other products are made from cocoa exported from producer countries. The amount of cocoa food and it derivatives per capita ranged between 0.1 and 7.5g/day through 17 groups of diet. The geometric mean of the occurrence levels for cocoa mass was multiplied by the corresponding per capita number to estimate the average population exposed to cadmium from cocoa products for each group of countries. These estimations were extrapolated to a monthly base multiplying daily exposure by 30, and then considered in relation to tolerance (PTWI).

Table 7. Summary of statistical descriptors for cadmium occurrence data

Cocoa product	Concentration (µg/kg)			
	Mean	Geometric mean	Median	97.5th percentile
Cocoa bean	751	467	570	2190
Cocoa beverage	35	22	21	160
Cocoa mass	136	103	88	537
Cocoa powder	130	86	130	430
Other cocoa products (including chocolate) (incluye chocolate)	76	34	32	361

Source: JECFA (2013). Cadmium: Assessment of exposure from cocoa and cocoa products

52. The estimates of mean population dietary exposure to cadmium from cocoa and its derivatives ranged from 0.005µg/kg bw per month (Cluster 13) to 0.39µg/kg bw per month (Cluster 7), assuming a 60kg bw, which equated to 0.2 to 1.6% of the provisional tolerable weekly intake (PTMI).

53. JECFA used the summary of consumption data derived from the individual records from a total of 36 different surveys on national consumption submitted by Brazil, China and the European Food Safety Authority (EFSA) for the national dietary exposure estimates. The estimation of the national dietary exposure to cadmium in beverages, cocoa powder and other cocoa products are summarized in Table 8, the data submitted for the whole population (mean amount) and only the consumers (mean and 97.5th percentile of food consumption amount value) were combined with the appropriate geometric mean of occurrence value.

54. The estimation of the mean dietary exposure to cadmium for the whole population between different age groups for cocoa beverages ranged from 0.02 to 0.14µg/kg bw per month (0.08 - 0.6% of the PTMI); from cocoa powder, from 0.001 to 0.13µg/kg bw per month (0.004 - 0.5% of the PTMI); and from other cocoa products, from 0.001 to 0.46µg/kg bw per month (0.004 - 1.8% of the PTMI). The estimation of the mean dietary exposure to cadmium between different population age groups for consumers of cocoa beverages ranged from 1.1 to 2.3µg/kg bw per month (4 - 9% PTMI); for consumers of cocoa powder, from 0.1 to 2.3µg/kg bw per month (0.4 to 9% of the PTMI); and for consumers of other cocoa products, from 0.2 to 1.1µg/kg bw per month (0.8 - 4% of the PTMI). The percentile 97.5, estimated from dietary exposure to cadmium between different population age groups for only consumers of cocoa beverages ranged from 2.8 to 11.9µg/kg bw per month (11 - 48% of the PTMI); only for consumers of cocoa powder, from 0.6 to 12.0µg/kg bw per month (2 – 48% of the IMTP); and for consumers of other cocoa products from 1.1 to 7.8µg/kg bw per month (4 - 31% of the PTMI) (JECFA, 2013).

Table 8. Dietary exposure estimates for cocoa derivatives

Cocoa product	Country / Region	Age group	Dietary exposure (µg/kg bw per month)		
			Whole Population	Consumers only	
				Mean	97.5th Percentile
Cocoa beverages	EU	Infants	-	-	-
		Toddlers[a]	-	2	-
		Other Children	0.058	2.3	11.9
		Adolescents	0.138	1.8	6.2
		Adults	0.037	1.2	5.2
		Elderly	0.020	1.5	4.7
		Very Elderly	0.017	1.1	2.8
Cocoa powder	EU	Infants[a]	-	0.4	-
		Toddlers	0.035	0.6	5.1
		Other children	0.085	0.6	12.0
		Adolescents	0.076	0.4	2.4
		Adults	0.006	0.1	0.6
		Elderly	0.004	0.1	0.6
		Very elderly	0.05	0.2	2.0
	China	General population	0.001	1.6	4.5
		Children[b]	-	-	-
		Women of childbearing age	0.002	2.3	8.8
	Brazil	General population	0.118	1.0	3.2
		Women of childbearing age	0.127	0.9	2.5
Other cocoa products	EU	Infants	0.006	0.8	1.5
		Toddlers[a]	0.302	1.0	3.7
		Other children	0.461	0.8	5.6
		Adolescents	0.257	0.5	4.4
		Adults	0.109	0.3	3.7
		Elderly	0.052	0.2	1.1
		Very elderly	0.056	0.2	1.4

Cocoa product	Country / Region	Age group	Dietary exposure (µg/kg bw per month)		
			Whole Population	Consumers only	
				Mean	97.5th Percentile
	China	General population	0.001	0.5	1.8
		Children	0.005	1.1	7.8
		Women of childbearing age	0.001	0.3	1.6
	Brazil	General population	0.051	0.9	4.4
		Women of childbearing age	0.067	0.9	4.2

Source:: EFSA (2013): *Cadmium: Assessment of exposure from cocoa and cocoa products*

[a] Number of consumers <11
[b] One consumer reported

PUBLIC HEALTH CONSIDERATIONS AND RISK MANAGEMENT

55. Many aspects were considered in the Commission Regulation (EU) No 488/2014 of 12 May, 2014, such as:

    - In some regions of the cocoa-producing countries, the levels of cadmium in the soil can be naturally high; therefore, the occurrence data in cocoa and chocolate, provided by countries with high levels of cadmium in the soil, should be taken into account when setting ML of cadmium.
    - To establish ML of cadmium, occurrence data for different types of chocolates and cocoa powder sold to final consumers should be considered. Since Cadmium levels in cocoa products are related to their cocoa content, it is convenient to set different ML of cadmium for products containing different percentages of cocoa. This ensures that the ML can also be achieved for chocolates with a higher percentage of cocoa.

56. After 1 January 2019, the EU will apply the following limits of cadmium for cocoa derivatives and chocolate:

    - Milk Chocolate with <30% total dry cocoa solids; 0.10mg/kg.
    - Chocolate with <50% total dry cocoa solids; milk chocolate with ≥30% of total dry cocoa solids; 0.30mg/kg.
    - Chocolate with ≥50% of total dry cocoa solids; 0.80mg/kg.
    - Cocoa powder sold to the final consumer or as an ingredient in sweetened cocoa powder sold to the final consumer (beverageing chocolate); 0.60mg/kg.

57. MERCOSUR (comprising Argentina, Brazil, Paraguay, Uruguay and Venezuela block) defined the limits of cocoa paste (0.5mg/kg); chocolate and cocoa products with <40% cocoa (0.2mg/kg); and chocolate and cocoa products with >40% cocoa (0.4mg/kg) (MERCOSUR/GMC/RES.N° 12-20011).

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