CODEX ALIMENTARIUS COMMISSION E

Food and Agriculture Organization of the United Nations

World Health Organization

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JOINT FAO/WHO FOOD STANDARDS PROGRAMME
CODEX COMMITTEE ON CONTAMINANTS IN FOODS
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PROPOSED DRAFT MAXIMUM LEVELS FOR CADMIUM IN COCOA AND COCOA-DERIVED PRODUCTS

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

Codex Members and Observers wishing to submit comments at Step 3 on the proposed draft maximum levels for cadmium in cocoa and cocoa 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). Codex Members and Observers are also invited to provide their views on the recommendations based on the conclusions presented on page 2. Information and data in support of the Conclusions and Recommendations contained in Appendix I is for information only.

Comments must be submitted before **15 March 2016** and should be directed:

to:	with a copy to:
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BACKGROUND

1. The 6th Session of the Committee on Contaminants in Foods (March 2012) was informed that a proposal for exposure assessment of cadmium (Cd) from cocoa and cocoa-derived products was made for inclusion in the priority list of contaminants and naturally occurring toxicants proposed for evaluation by Joint FAO/WHO Expert Committee on Food Additives (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 CCCF6, the exposure assessment to Cd from cocoa and cocoa-derived products was considered by the 77th JECFA Meeting (June 2013). The outcome of the JECFA meeting was considered by the 8th Session of the Committee (April 2014).

3. At the 8th Session of the Committee, the delegation of Ecuador presented a proposal for new work on Maximum Levels - ML for Cd in chocolate and cocoa derived products based on the assessment of the in-session Working Group on Priorities which had met during this session. The Delegation noted that while the JECFA assessment (77th Meeting) reported that Cd intake by eating chocolate and cocoa products was not of health concern, the lack of a ML for Cd in cocoa and its products could threaten the exports of some member countries, especially developing countries which were the main exporters of cocoa. The Committee agreed to initiate a new work on MLs for cadmium in chocolate and cocoa derived products.[2]

4. The 37th Session of the Codex Alimentarius Commission (July 2014), approved the new work proposed by the CCCF.[3]

[1] REP12/CF, paras 159, 161
[2] REP14/CF, paras 141-142
[3] REP14/CAC, Appendix VI

5. At the 9th Session of the Committee (March 2015), it was agreed to reestablish the Electronic Working Group, chaired by Ecuador and co-chaired by Brazil and Ghana to reconsider the proposed draft for MLs for Cd in chocolate and cocoa - derived products, taking into account the comments made at that session. The EWG should clearly identify the products for which the MLs were being established and provide the rationale for the MLs.[4] The List of Participants is contained in Appendix II.

6. For this reason 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 10th CCCF Meeting. Supporting technical information is presented in Appendix I which is not subject to comments.

CONCLUSIONS

- Cocoa production is associated mainly with organic and conventional farmers for whom cocoa production is the basis of the family income.
- To establish the proposed ML, results on occurrence of Cd found worldwide was taken into consideration.
- Due to the lack of a clear categorization for chocolates and little or no available data on the occurrence of Cd for these products, gathering more information in order to progress in the discussions on the establishment of ML for chocolates is necessary; therefore the EWG has not been able to unify criteria to establish ML for such products.
- Taking into consideration the section of the Procedural Manual on “Number of commodities which would need separate standards indicating whether it is raw, semi processed or processed product” it has been considered to separate the cocoa beans from their sub products, in order to propose in this paper, the establishment of MLs only for liquor and cocoa powder. This is because the beans and cocoa nibs are products that are not consumed directly, as they must first undergo an industrial transformation processing to obtain the sub products such as: liquor, cocoa powder and butter, which are the raw materials for the production of chocolates and cocoa derived-products.
- However, according to JECFA evaluation (77th Meeting),it was noted that the total exposure of Cd in diets with high levels of cocoa consumption and cocoa products was apparently overestimated and JECFA did not consider Cd to be of concern in these products.
- Comparing the available data from GEMS/Food and CAOBISCO, it can be shown that the concentration profile of Cd in samples from Latin America (CAOBISCO) are higher than the samples obtained from GEMS / Food (unknown origin), for those sub products.
- For samples of cocoa powder, it was evidenced that more than 98% of the analyzed data are below 0.6 mg/kg of Cd (obtained from the GEMS/Food database). From the CAOBISCO obtained data, it was found that 33.51% of the data does not exceed 0.6 mg/kg of Cd, showing that the Cd concentration levels for cocoa powder are higher in samples from Latin America.
- According to the availability of the above detailed data, the establishment of an ML of 3.0 mg/kg for Cd in cocoa liquor, affects 1.4% of world trade and in the case of cocoa powder with a level of 4.0 mg/kg of Cd affects 0.46%, considering samples from different origins, analysis that was used to determine the establishment of ML for these products. It was also shown that with the PTMI calculated from these data (7.69% and 4.15% for liquor and cocoa powder, respectively), the consumption of cocoa with the worst case scenario (Cluster Diet 7) does not affect consumers’ health.

RECOMMENDATIONS

- The EWG recommends to work on the categorization for different types of chocolates and subsequently recommends gathering of scientific data on the occurrence of Cd in samples of chocolate based on the different categories.
- The EWG recommended to request CCMAS to standardize the evaluation methods for the determination of Cd in cocoa and its sub-products.
- According to the information obtained from the GEMS/Food and CAOBISCO, the EWG would like to suggest the following ML for Cd in cocoa liquor and cocoa powder:

Table Proposal ML of Cd in chocolate and cocoa and cocoa derived products.

PRODUCT	ML of Cd (mg/kg)
Cocoa liquor	3.0
Cocoa powder	4.0

[4] REP15/CF, paras 52 - 55

APPENDIX I – INFORMATION IN SUPPORT OF THE CONCLUSIONS, RECOMMENDATIONS AND MAXIMUM LEVELS PROPOSED

INTRODUCTION

7. Contamination of heavy metals in human diet has become a topic of concern in many countries around the world, for its high concentration may cause health problems in humans. The 73th Session of JECFA, previously identified major contributors to Cd exposure as cereals/grains, vegetables, meat and poultry offal, and seafood (especially shellfish).

8. JECFA evaluation (77th Meeting) stressed that the total exposure of Cd in diets with high levels of consumption of cocoa and cocoa derived products was apparently overestimated and did not consider it as a concern.

9. In 2014, the European Union announced by Regulation (EU) No 488/2014 plans to implement regulations to chocolate and cocoa products containing certain levels of Cd, which will take effect from 1 January, 2019.

DEFINITIONS

10. In this document the following concepts are defined:

- **Cocoa:** Fruit of the trees of the species *Theobroma cacao*.
- **Cocoa bean:** The seed of the cacao fruit (*Theobroma cocoa)*; commercially, and for the purpose of this document, the term refers to the whole seed which has been fermented and dried.
- **Cocoa cake:** Is the product obtained by partial or complete removal of fat from cocoa seeds or cocoa mass.
- **Cocoa Liquor:** Is the product obtained from cocoa nib, which is obtained from cocoa beans of merchantable quality, which have been cleaned and freed from shell with the most technically complete method, without removing or adding any of its constituent's elements.
- **Cocoa Butter:** Is the fat obtained from cocoa beans with the following characteristics: Free fatty acids (expressed as oleic acid): not more than 1.75% m/m; unsaponifiable matter: not more than 0.7% m/m, except in the case of press cocoa butter that should not exceed 0.35% m/m.
- **Nibs:** Small fragments of cocoa beans roasted at different temperatures according to the formula established by the manufacturer.
- **Cocoa powder:** Product obtained from cocoa cake transformed into powder.
- **Percentage of cocoa solids:** It refers to the total percentage of ingredients by weight in the product that comes from the cocoa bean, including liquor and cocoa butter.
- **Non-fat cocoa solids:** Are all cocoa components (carbohydrates, fibre, protein and minerals), which were subtracted the fat and moisture.
- **Total cocoa solids:** Are all cocoa components, therefore, is the sum of the fat or cocoa butter plus no fatty components (non-fat cocoa solids).

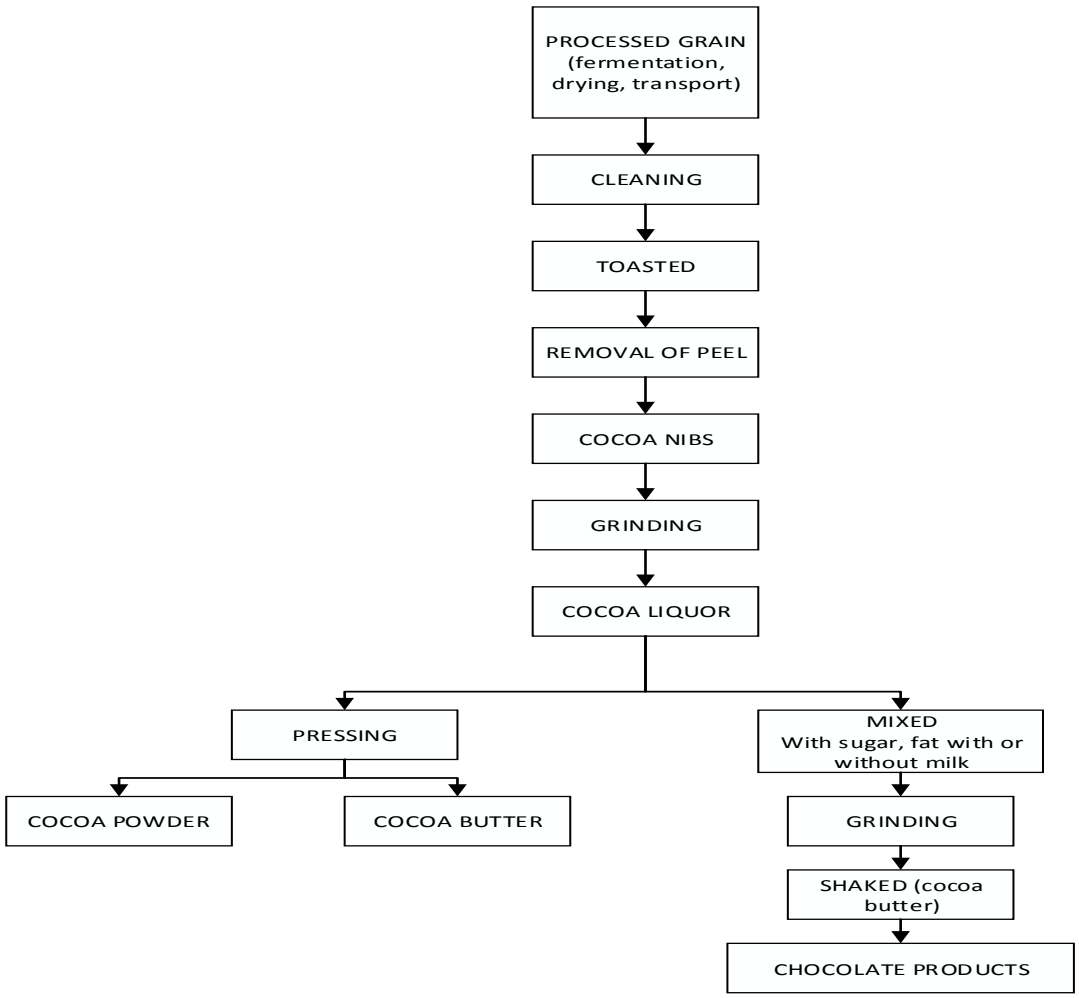
ACRONYMS

11. The following acronyms are mentioned:

- **CAC:** Codex Alimentarius Commission
- **Cd:** Cadmium
- **EWG:** Electronic Working Group
- **CCCF:** Codex Committee on Contaminants in Foods
- **FAO:** Food and Agriculture Organization of the United Nations
- **ICCO:** International Cocoa Organization
- **JECFA:** Joint FAO/WHO Expert Committee on Food Additives
- **LOD:** Limit of Detection
- **LOQ:** Limit of Quantification
- **m/m:** mass/mass
- **ML:** Maximum Levels
- **bw:** bodyweight
- **PTMI:** Provisional Tolerable Monthly Intake
- **EU:** European Union
- **GEMS:** Global System for Environmental Monitoring
- **WHO:** World Health Organization

COCOA PROCESSING

12. Cocoa marketed worldwide is a product of fermentation and drying process. The cocoa beans are not consumed as such, because it must first be subjected to a process of industrial transformation prior to consumption (Figure 1).



Source: Adapted from Beckett, 2008.

Figure 1. Schematic diagram of process of cocoa and its derivatives.

ECONOMIC IMPORTANCE OF COCOA WORLDWIDE

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

Table 1. World production of cocoa beans, (2012-2015).

COUNTRY	Thousands of tons					
	2012-2013		Estimated value (2013-2014)		Estimated value (2014-2015)	
AFRICA	**2 836**		**3 197**		**2 984**	
Cameroon	225		211		220	
Ivory Coast	1 449	**71.9%**	1 746	**73.3%**	1 740	**71.6%**
Ghana	835		897		696	
Nigeria	238		248		235	
Others	89		95		93	
AMERICA	**622**		**708**		**729**	
Brazil	185	**15.8%**	228	**16.2%**	215	**17.5%**
Ecuador	192		220		250	
Others	246		260		264	
ASIA AND OCEANIA	**487**		**454**		**455**	
Indonesia	410	**12.3%**	375	**10.4%**	370	**10.9%**
Papua New Guinea	41		40		42	
Others	36		38		43	
TOTAL WORLD	**3 945**	**100%**	**4 359**	**100%**	**4 168**	**100%**

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

Source: ICCO Quarterly Bulletin of Cocoa Statistics, Vol XLI, No.2, Cocoa Year 2014/15. 05/29/2015. Published: 27-02-2015.

14. Europe demands most of cocoa beans (Table 2) for the production of cocoa nibs. These grindings will be processed into cocoa products (ICCO, 2007). The vast majority of imports of cocoa comes from West Africa (93%); imports from Latin America and Southeast Asia are secondary and tertiary, respectively (ICCO, 2012).

Table 2. Grindings of cocoa beans (2011-2014).

COUNTRY	Ground grains consumption (Thousands of tons)					
	2011/2012		2012/2013		2013/2014	
EUROPE	**1 521**		**1 581**		**1 620**	
Germany	407	**38.4%**	400	**38.8%**	418	**38.8%**
Netherlands	500		535		545	
Others	614		646		657	
AFRICA	**717**		**769**		**797**	
Ivory Coast	431	**18.1%**	471	**18.9%**	500	**19.1%**
Ghana	212		225		230	
Others	74		73		67	
AMERICA	**845**		**881**		**889**	
Brazil	242	**21.4%**	241	**21.6%**	240	**21.3%**
USA	387		412		415	
Others	216		228		234	
ASIA AND OCEANÍA	**874**		**846**		**872**	
Indonesia	270	**22.1%**	255	**20.8%**	275	**20.9%**
Malaysia	297		293		290	
Others	307		298		307	
TOTAL WORLD (COCOA GRAINS)	**3 957**	**100%**	**4 077**	**100%**	**4 178**	**100%**
TOTAL WORLD (GRINDING)	**1 728**	**43.7%**	**1 759**	**43.1%**	**1 810**	**43.3%**

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

Source: ICCO Quarterly Bulletin Cocoa Statistics. Vol. XI, No. 1, Cocoa year 2013/2014. Published: 28/02/2014.

15. According to Trade Map, in 2014 chocolate and other food preparations containing cocoa represented 47.8% of global imports followed by cocoa beans and nibs (27.4%), cocoa liquor (8.4%), cocoa butter (8.3%), cocoa powder without added sugar (7.2%), and cocoa shells, husks, skins and other cocoa waste (0.9%). (Trade Map, 2014).

16. The world cocoa market recognizes two broad categories of cocoa beans: “fine or flavour” cocoa and “bulk” or “common” cocoa. Generally, the fine or flavour cocoa is produced by trees from Criollo or Trinitario variety, while bulk cocoa comes from the tree Forastero variety. There are exceptions, such as in Ecuador, the National Cocoa trees, considered Forastero variety, produce fine or flavor cocoa. Another exception is Cameroon, the cocoa produced by trees of Trinitario variety is considered common cocoa. 95% of the world's annual cocoa production is bulk, which occurs mostly in Africa, Asia and Brazil. (ICCO, 2011).

17. According to the ICCO, Latin American countries provide 17.5% of world cocoa production. In the region there are 500 000 farms of cocoa, with more than 3 500 000 small farmers for whom cocoa production is the basis of their economy[5].

[5] REP14/CF, Appendix XI

METHODS OF ANALYSIS

18. Methods of analysis to determine Cd 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 incineration - 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. The General Methods of Analysis for Contaminants (CODEX STAN 228-2001) recommends some Cd analysis methods such as atomic absorption spectrometry (AAS) after incineration or microwave digestion and Anodic stripping voltammetry.

20. Table 3 presents the LOD (detection limit) for Cd by different analysis methods mentioned above.

Table 3. Detection limits with different methods.

Technique	Detection limit (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. Taking into account the performance criteria for analysis, set out in the Procedural Manual of the Codex Alimentarius Commission, several methods not included in the CODEX STAN 228-2001 could be used for analysis of Cd.

22. Laboratories may select any valid method of analysis; however, the method selected should meet the criteria described in the Procedural Manual of the Codex Alimentarius Commission, Table 4.

23. Performance criteria required for maximum levels over 0.1 mg.kg^{-1} established in the Procedural Manual of the Codex Alimentarius Commission are the same as those established in the EU regulation for limit of detection (LOD), limit of quantification (LOQ) and precision. The recovery should have a range from 80% to 110%.

Table 4. Performance criteria for methods of analysis.

Parameters	ML for ≥ 0.1 mg/kg	ML for < 0.1 mg/kg
Minimum Applicable Range	[ML - 3 s_R, ML + 3 s_R] s_R = reproducibility standard deviation	[ML - 2 s_R, ML + 2 s_R] s_R = reproducibility standard deviation
LOD	Less than one tenth of the ML	Less than a fifth of the ML
LOQ	Less than a fifth of the ML	Less than a fifth of the ML
Precision	HorRat Value ≤ 2	RSD_{TR} < 22% RSD_R= reproducibility standard deviation $RSD_R \leq 2.\ PRSD_R$
Recovery (%)	80 - 110 (from 0.1 to 10 mg/kg)	60 - 115 (for 0.01 mg/kg)
Trueness	Other guidelines are available for expected recovery ranges in specific areas of analysis. In cases where recoveries have been shown to be a function of the matrix other specified requirements may be applied. For the evaluation of trueness preferably certified reference material should be used.	

Source: CAC, 2015.

TOXICOLOGICAL EVALUATION

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

25. In occupational exposure, inhalation is the main route of entry and absorption from this path depends on the type of compound inhale, particle size and its retention in the lung, In non-occupational exposures, diet is the most important source of intake of Cd, The absorption from the gastrointestinal tract is approximately 50% (Ramirez, 2002).

26. Vegetables and cereals are the main sources of Cd concentration in the diet, although Cd is found in meat and fish to a lesser extent, while crustaceans and molluscs can accumulate large amounts from the aquatic environment (Satarug, 2010).

27. Cd was evaluated in Sessions 16, 33, 41, 55, 61, 64, 73 and 77 of JECFA. In 2010, JECFA decided to express the tolerable intake as a monthly value, establishing a Provisional Tolerable Monthly Intake (PTMI) of 25µg/kg b.w.

28. JECFA estimation on exposure to Cd of products containing cocoa and its derivatives for the average population diet in the 17 GEMS / Food dietary groups ranged from 0.005 to 0.39 µg/kg bw/month, which is equivalent to 0.02 to 1.6% of PTMI. This represents an estimation of the Cd average dietary exposure of cocoa and its derivatives for the entire population. Similar dietary exposures of Cd in the population for individual cocoa products were estimated from national data, ranged from 0.001 to 0.46 µg/kg bw/month (0.004 to 1.8% PTMI). The potential food exposure to Cd for large consumers of products containing cocoa and its derivatives, besides other food containing Cd were estimated between 30 to 69% PTMI for adults and 96% PTMI for children from 0.5 to 12 years old. The Committee noted that this Cd total dietary exposure to large consumers of cocoa and its products, was probably overestimated and did not consider it cause for concern (JECFA, 2013).

CADMIUM OCCURRENCE IN COCOA BY PRODUCTS SAMPLES

29. As described above, the cocoa beans and nibs represent 27.4% of world trade, however, these products are not directly consumed because they must first undergo to an industrial processing transformation to obtain byproducts as liquor, powder and cocoa butter, raw material for the production of chocolates and cocoa derived products.

30. Taking into account the above and following the Procedures Manual (24th Edition) on its section “Number of commodities which would need separate standards indicating whether raw, semi-processed or processed”; it has been considered to separate the cocoa bean (raw product) from their products: liquor, powder and cocoa butter, for the purposes of this document.

31. According to Yanus et *al.* (2014), the processing to obtain powder and cocoa butter influences the distribution of Cd, where over 95% it is accumulated in cocoa powder.

32. Considering a process under standardized conditions, it is known that from 1.0 kg of cocoa liquor, 0.6 kg of cocoa powder and 0.4 kg of cocoa butter are obtained. Taking into account that the entire content of Cd remains in the fat-free cocoa solids, cocoa powder would have a concentration factor of 1.67; since then the data for cocoa powder Latin America were calculated.

33. Knowing that the concentration of Cd in cocoa butter is low, priority has been given to the establishment of ML for liquor and cocoa powder, which are raw materials for the chocolate production.

34. Cocoa liquor is not directly consumed, but is used as an ingredient for the manufacture of chocolate and baked products, it can be used in different types of chocolate products in general ranges between 10-90% of the formulation.

35. Likewise it occurs with the cocoa powder, which is either directly consumed as such, since it is used as an ingredient in various types of products; for example, as a component in bakery products, it can contribute approximately 5% of the formula; and in a drinking chocolate powder, it can contribute with only 30%, to being diluted later in water or milk before its final consumption.

36. Lee & Low (1985) evaluated intermediate products in the stages of chocolate manufacturing (roasted cocoa, liqueur, paste, cake, nibs and shell). They noted that there is contamination in the involved processes and they also noted that the addition of ingredients such as milk and sugar does not contribute effectively into metal increasing concentrations.

37. To analyze the Cd concentration in samples of cocoa liquor and cocoa powder, the EWG prepared data tables, in which the range of occurrence and percentage of quantified samples are shown.

38. Tables 5 and 7 were made with data based on GEMS / Food (WHO), which were provided by countries like Germany, Denmark, France, Czech Republic, Singapore and Sweden (imported products from unknown sources).

39. While Tables 6 and 8 are made with data from some cocoa producer countries of Latin America (CAOBISCO) such as Colombia, Costa Rica, Cuba, Ecuador, Mexico, Peru, Dominican Republic and Venezuela.

- **Cd in cocoa liquor samples**

40. In Table 5 it can be seen that 91.58% of the samples (set of 87 observations of a total of 95 samples) is below 0.3 mg/kg, while 8.42% exceeds this value.

Table 5. Distribution of Cd content in samples of cocoa liquor.

Occurrence Range (mg/Kg)	No. Quantified samples	Percentage (%)
≤ 0.1	*60*	*63.16*
>0.1 ≤ 0.2	*20*	*21.05*
>0.2 ≤ 0.3	*7*	*7.37*
>0.3	8	8.42
TOTAL	95	100.00

Source: SIMUVIMA/Food

Written by: EWG, 2015

41. Occurrence data of Cd in cocoa liquor that shown in Table 6 indicate that 74.6% of the samples are over 0.3 mg/kg of Cd and only 23.6% of the samples do not exceed this value.

Table 6. Distribution of Cd content in samples of cocoa liquor of Latin America.

Occurrence Range (mg/kg)	No. Quantified samples	Percentage (%)
≤ 0.3	45	23.60
>0.3 ≤ 0.5	52	27.20
>0.5 ≤ 1	*48*	*25.10*
>1 ≤ 2	*33*	*17.30*
>2 ≤ 3	*9*	*4.70*
> 3	*4*	*2.10*
TOTAL	191	100.00

Source: CAOBISCO

Written by: EWG, 2015

- **Cd in samples of cocoa powder**

42. According to Table 7, it is observed that from 1120 samples, 96.7% do not exceed 0.4 mg/kg Cd content; furthermore 1.08% of samples lie in a range of Cd occurrence of more than 0.6 mg/kg Cd, for cocoa powder (12 observations).

Table 7. Distribution of Cd content in samples of cocoa powder.

Occurrence Range (mg/Kg)	No. Quantified samples	Percentage (%)
≤ 0.2	*1 024*	*91.43*
>0.2 ≤ 0.4	*59*	*5.27*
>0.4 ≤ 0.6	25	2.23
>0.6 ≤ 0.8	*6*	*0.54*
>0.8	*6*	*0.54*
TOTAL	1 120	100.00

Source: SIMUVIMA/Food

Written by: EWG, 2015

43. Based on Cd concentrations in cocoa liquor from Latin America (Table 6) and using the concentration factor (1.67), data on the presence of Cd in the cocoa powder was calculated, as expressed in Table 8.

44. In that Table 8 it can be seen that 65.96% of the Cd content in cocoa powder samples is higher than 0.6 mg/kg, also 3.66% of samples exceed 4.0 mg/kg.

Table 8. Estimated distribution of Cd content in cocoa powder from cocoa liquor data in Latin America.

Occurrence Range (mg/Kg)	No. Quantified samples	Percentage (%)
≤0.2	*7*	*3.66*
>0.2 ≤ 0.4	*24*	*12.57*
>0.4 ≤ 0.6	*33*	*17.28*
>0.6 ≤ 0.8	*32*	*16.75*
>0.8 ≤ 1.5	38	19.90
>1.5 ≤ 3	42	21.99
>3 ≤ 4	7	3.66
>4	*7*	*3.66*
TOTAL	190	100.00

Source: CAOBISCO

Written by: EWG, 2015

- **Analysis of Cd occurrence in liquor and cocoa powder**

45. Making a comparison between Tables 5 and 6 (cocoa liquor) and Tables 7 and 8 (cocoa powder) it can be shown that the concentration profile of Cd in samples from Latin America (CAOBISCO) are higher than the samples obtained from GEMS / Food (unknown origin), for those products.

POTENTIAL IMPACT OF ML BY MEAN EXPOSURE TO CADMIUM IN COCOA SUBPRODUCTS ON FOOD DIET

46. To assess the impact of proposed ML for Cd in cocoa sub products dietary exposure on the occurrence of liquor and cocoa powder (CAOBISCO and GEMS / Food) available data was used.

47. Per capita consumption of cocoa and its derivatives ranged from 0.1 to 7.5 g / day through the 17 cluster diets GEMS / Food. Group 7 has the highest cocoa consumption in the diet, so it can provide a limit of ML suitable, as it would serve as the worst global scenario regarding Cd intake for this cluster diets, same as it includes the following countries: Australia, Bermuda, Finland, France, Iceland, Luxembourg, Norway, Switzerland, United Kingdom and Uruguay (WHO, 2015).

48. The impact of different proposed ML on mean estimates of dietary exposure to Cd in the liquor and cocoa powder, using different diet groups is shown in Table 10. The proposed ML liquor and cocoa powder was multiplied by the corresponding per capita consumption, in order to estimate exposure to Cd in the diet of the average population of the Group 7. These estimates were extrapolated to a monthly basis by multiplying the daily exposure for 30, then the relationship is considered to PTMI.

Table 10. Summary of the impact of different ML for Cd in the statistical distribution of Cd in the liquor and cocoa powder Latin American countries and other sources, including the proportion expected PTMI Cd intake for the diet group 7 and the proportion of rejected samples provided in the global market.

Scenario	No. samples	Average Content of Cd (mg/kg)	Cd intake (g/lg monthly p.c.)	PTMI (%)	Possible rejected samples (%)
COCOA LIQUOR					
Without ML	285	0.57	2.14	8.55	0 - 100
ML: 3.0 mg/kg	281	0.51	2.92	7.69	1.40
ML: 2.0 mg/kg	272	0.45	2.69	6.78	4.56
ML: 1.0 mg/kg	239	0.33	1.23	4.92	16.14
ML: 0.5 mg/kg	187	0.21	0.77	3.09	34.39
ML: 0.3 mg/kg	133	0.13	0.50	1.98	53.33
COCOA POWDER					
Without ML	1310	0.30	1.130	4.52	0 - 100
ML: 4.0 mg/kg	1304	0.28	1.037	4.15	0.46
ML: 3.0 mg/kg	1296	0.26	0.961	3.84	1.07
ML: 2.0 mg/kg	1273	0.22	0.822	3.29	2.82
ML: 1.0 mg/kg	1223	0.17	0.626	2.50	6.64
ML: 0.5 mg/kg	1139	0.13	0.480	1.92	13.05
ML: 0.3 mg/kg	1068	0.11	0.410	1.64	18.47

*b.w considered: 60 kg

Source: EWG, 2015

49. Considering the Diet Group 7 as the worst case scenario worldwide for being the highest intake of cocoa in the “Cocoa, cola and their non-liquid derivates” diet (according to Table “Cluster Diet 2012” of WHO) and after making the above calculation it appears that without a ML of Cd, the intake would represent only 8.55% for cocoa liquor and 4.52% for cocoa powder from a total of 25 µg/kg bw PTMI, as was previously reported by JECFA.

50. It can be observed that with the ML of 3.0 mg/kg and 4.0 mg/kg for cocoa liquor and cocoa powder respectively, the PTMI calculated with the available data is 7.69% for cocoa liquor and 4.15% for cocoa powder; it should be highlighted that the percentages of PTMI above indicated were calculated considering cocoa liquor and cocoa powder as the only source of this metal concentration and assuming that they are the only source of food in the diet; however, it is important to emphasize that the Cd is also present in other foods commonly consumed in greater quantities.

51. For the above detailed it is demonstrated that ML of 3.0 mg/kg for cocoa liquor and 4.0 mg/kg for cocoa powder, do not exceed the PTMI suggested by JECFA (0.025 mg/kg) and therefore will not cause harm to consumer´s health. Table 10 shows that these values could lead to a rejection of 1.40% and 0.46% respectively of semi-elaborated products.

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APPENDIX I: ANNEXES

ANNEX I

- **Exercise of estimated monthly consumption of Cd in samples of cocoa liquor**

DATA

Bodyweight: *60kg*

PTMI: *0.025 mg/kg pc*

Diet group (G07): *7.5g.day*

Average Cd content (in 281, with ML of 3.0 mg/kg):0.51 mg/kg

MATHEMATICAL OPERATIONS

Monthly intake = 7.5 g * 30 days

Monthly intake = 225 g/month → 0.225 mg/month

Monthly intake = (0.225 mg/month) / 60 kg = 0.00375 mg/kg

Intake of Cd (ug/kg bw monthly) = 0.00375 mg/kg * 0.51 mg/kg = 0.0019125 mg/kg

PTMI (%) = 0.025 → 100%

0.0019125 → X

PTMI (%) = 7.69

ANNEX II

- **Exercise of estimated monthly consumption of Cd in samples of cocoa powder**

DATA

Bodyweight: 60 kg

PTMI: 0.025 mg/kg pc

Diet group (G07): 7.5 g/day

Average content of Cd *(in 281, with ML of 3.0 mg/kg):* 0.28 mg/kg

MATHEMATICAL OPERATIONS

Monthly intake = 7.5 g * 30 days

Monthly intake = 225 g/month → 0.225 mg/month

Monthly intake = (0.225 mg/month) / 60 kg = 0.00375 mg/kg

Intake of Cd (ug/kg bw monthly) = 0.00375 mg/kg * 0.28 mg/kg = 0.00105 mg/kg

PTMI (%) = 0.025 → 100%

0.00105 → X

PTMI (%) = 4.15

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