CODEX ALIMENTARIUS COMMISSION

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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DISCUSSION PAPER ON THE DEVELOPMENT OF A CODE OF PRACTICE FOR THE PREVENTION AND REDUCTION OF CADMIUM CONTAMINATION IN COCOA

(Prepared by the Electronic Working Group led by Peru)

BACKGROUND

1. At the 11th Session of the Codex Committee on Contaminants in Foods (CCCF11, 2017) Peru introduced a proposal for the development of a code of practice (COP) to guide Member States and the cocoa production industry in preventing and reducing cadmium contamination in cocoa beans during the production and processing phases. CCCF agreed to establish an EWG, led by Peru, working in English, to prepare a discussion paper and project document for discussion on the opportunity to develop such COP and the risk mitigation measures available to that would support the development of a COP.

2. At CCCF12 (2018), Peru presented the draft and stressed the usefulness of administering a survey to gather information on validated practices throughout the food chain for the prevention and reduction of cadmium contamination in cocoa prior to starting new work on the development of a COP. To gather this information, CCCF agreed that a circular letter would be prepared for the survey and distributed by the Codex Secretariat. The view was expressed that in the conclusions the only points that should be listed are those which are relevant for the development of the COP.

3. In addition, the JECFA Secretariat requested CCCF to pay special attention to the mitigation measures that would be feasible even for small farmers, since they were the most affected by this issue. CCCF agreed to re-establish an EWG chaired by Peru, co-chaired by Ghana and Ecuador to continue developing the discussion paper to:

   i.) Determine if the mitigation measures currently available would support the development of the COP;

   ii.) Identify the scope of the COP (for example, if the COP will cover the entire production chain or only primary production) according to the responses provided to the survey.

   iii.) And if the above conditions i) and ii) are met, then the EWG must provide a project document and a first draft of a COP. The EWG should focus its work on mitigation measures that have proven to be cost effective and applicable worldwide by large and small producers.

4. The conclusions and recommendations of the EWG for consideration by CCCF are described below. A project document on the proposal for new work on the development of a COP to prevent and reduce cadmium contamination in cocoa beans are presented in Appendix I for consideration by CCCF.

5. An outline of the COP is presented in Appendix II for general review by CCCF in order to provide guidance to the EWG in the further development of the COP if such work is recommended for approval by CAC in 2019.

6. The discussion paper providing the basis for the conclusions, recommendations and the proposal for new work (Appendix I) is presented in Appendix III for information to assist Codex members and CCCF in making a decision on the appropriateness of new work on a COP for the prevention and reduction of cadmium contamination in cocoa beans.

CONCLUSIONS

7. After receiving comments in reply to circular letter CL 2018/73-CF[1], the EWG **determined that current available mitigation measures support the development of a code of practice in the area of cocoa field production and post-harvest (fermentation, drying and storage processes)** in the cocoa value chain applicable to small, medium and large producers. The reason behind the need for the COP is to provide countries with management practices to minimize cadmium contamination and to support the implementation of maximum levels of cadmium in chocolate and cocoa products.

8. This COP provides current and relevant information so that all countries consider in their efforts the measures to prevent and reduce the contamination of cadmium in cocoa beans, considering that cadmium (Cd) in cocoa and its derivatives must be managed in an integral manner. For this COP to be effective, it will be necessary for national authorities**,** national research institutes, producers, traders and primary processors in each country to consider the general principles and examples of good agricultural practices (GAPs) and good manufacturing practices (GMPs) provided in the *General Principles of Food Hygiene* (CXC 1-1969), taking into account its climate and agronomic practices to allow and facilitate the adoption of these practices when relevant and feasible.

9. Cocoa beans from different jurisdictions in a district, different districts of a province and regions within a country and between different countries have a wide range of cadmium levels.

10. At the moment, there is no manufacturing process that can effectively reduce cadmium levels in cocoa or chocolate products. Therefore, the COP will not include manufacturing processes.

11. Codex member countries and observer organizations participating in the EWG reported that they are conducting several studies to mitigate Cd contamination, whose information and data will be available this and next year. Such studies as they become available can be incorporated in the COP during its development or at a later stage. However, current available practices can still support the development of a COP covering field and post-harvest production.

12. Cocoa producers should be trained to follow GAP and maintain a close relationship with agricultural advisers, extension services and agri-food safety authorities to obtain information and advice on the choice of appropriate cocoa bean cultivars and appropriate plant protection products for use in their respective production regions to reduce the incidence and levels of cadmium

13. To avoid contamination of cocoa by cadmium through air, water and agricultural land, national agri-food authorities, together with other public and private sectors, must take measures to: (i) control the emissions of the industry: mining, metals (ii) control the emissions of the means of transport, (iii) control the disposal of domestic and industrial solid and liquid waste, including its disposal in the land, the elimination of sewage sludge and incineration of municipal waste, (iv) control the production, commercial use and disposal of substances that persist in the environment, such as cadmium compounds, and (v) ensure that before new pesticides are introduced into the market, they should have been subject to appropriate analysis to demonstrate their acceptability from the point of view of health and the environment.

RECOMMENDATIONS

14. The EWG makes the following recommendations to CCCF:

- CCCF confirms that there is sufficient information on mitigation measures to support the development of a code of practice in the area of cocoa field production and post-harvest (fermentation, drying and storage processes);
- CCCF agrees to forward the project document in Appendix I for the development of a COP for the prevention and reduction of cadmium contamination in cocoa beans for approval as new work by the Codex Alimentarius Commission (CAC42, 2019);
- CCCF establishes an EWG to prepare a proposed COP for comments and consideration by CCCF14; and
- CCCF provides general comments on the proposed COP as presented in Appendix II to guide the work of the EWG in the further development of the COP.

15. In considering the above recommendations, CCCF is invited to take into account the technical information provided in Appendix III as well as the conclusions in paragraphs 7 – 13.

[1] CL 2018/73-CF Request for comments and information on management practices for the prevention and reduction of cadmium contamination in cocoa and Cocoa products. Comments submitted by Ecuador, Bolivia, Brazil, Canada, Colombia, Peru, United Kingdom, Food Drink Europe and International Confectionery Association

APPENDIX I

PROJECT DOCUMENT

PROPOSAL FOR NEW WORK ON A CODE OF PRACTICE FOR THE REDUCTION AND PREVENTION OF CADMIUM CONTAMINATION IN COCOA BEANS

(For consideration by CCCF)

1. **The purpose and scope of the project**

The purpose of the new proposal is to develop a Code of Practice (COP) that will provide guidance to Member States and the cocoa production industry on the prevention and reduction of cadmium (Cd) contamination in cocoa beans during production and post-harvest processing: fermentation, drying and storing.

The scope of the work intends to provide country´s authorities or food safety authorities, small, medium or large producers and other relevant organizations, guidance on recommended measures to prevent and reduce cadmium contamination in cocoa: Before planting or in new plantations, during the production stage until harvest and in the post-harvest stage. This COP applies to the cocoa beans marketed internationally.

2. **Relevance and timeliness**

The 11th Session of the Committee on Contaminants in Foods (CCCF11) (2017) agreed1 that Peru would lead an electronic working group (EWG) to prepare a discussion paper on the development of a Code of practice for the prevention and reduction of cadmium contamination in cocoa.

At CCCF12 (2018), Peru presented the preliminary draft and highlighte the usefulness of administering a survey to gather information on validated practices throughout the food chain for the prevention and reduction of cadmium contamination in cocoa prior to starting new work on the development of a COP. To gather this information, CCCF agreed that a circular letter would be prepared for the survey and distributed by the Codex Secretariat. The view was expressed that in the conclusions the only points that should be listed are those which are relevant for the development of the COP.

At its 77th Session (2013), the Joint FAO / WHO Expert Committee on Food Additives (JECFA) determined that the estimates of mean population dietary exposure to Cd from products containing cocoa and its derivatives for the 17 GEMS/Food Cluster Diets ranged from 0.005 to 0.39 µg/kg bw (body weight) per month, which equated to 0.02 – 1.6% of the Provisional Tolerable Monthly Intake (PTMI) of 25 µg/kg bw.

The entry into force of the European Union Regulation 488/2014 on 1 January 2019 on maximum levels (MLs) of Cd in foodstuffs including chocolates and cocoa products makes it necessary a Code of Practice that outlines measures to prevent and reduce Cd in cocoa contamination to levels so low as reasonable achievable (ALARA) in order to mitigate Cd exposures and support fair trade.

3. **Main aspects to be covered**

Code of practice for the prevention and reduction of cadmium contamination in cocoa beans taking into consideration the following:

a) Production system (conventional, organic, mixed plantations with agroforestry).
b) Cocoa crop factors that determine Cd absorption by plants.
c) Strategies to immobilize Cd and decrease its availability in soil
d) Phyto extraction of heavy metals (Cd): Agronomic management of the cocoa crop, Cocoa physiology, Cd bioaccumulation in cocoa beans.
e) Growing and plantation areas, soil amendments and its cost efficiency, especially for small cocoa farmers, pruning, optimal time of harvest.
f) Cocoa genetics (germplasm, clones)
g) Post-harvest technology (fermentation, drying, storing),

4. **An assessment with regard to the criteria for setting priorities for work.**

General criterion

This COP will outline a range of agricultural and primary processes that will help to reduce levels of Cd in cocoa and cocoa products to levels that are safe for human beings, emphasizing that there is an EWG chaired by Ecuador and cochaired by Brazil and Ghana that is proposing a Codex MLs for chocolate and cocoa derived products.

a. Diversification of national legislation and apparent resultant or potential impediments to international trade

This COP will provide a consistent source of guidance to cocoa producers and post-harvest processors in all of Member States to prevent and reduce cadmium contamination in cocoa beans. It will thus provide assurance to exporters that levels of Cd in cocoa and cocoa products meet the ALARA principle, and also Codex Maximum Levels (ML) of Cadmium in chocolates and cocoa derived products that are under development.

b. Scope of work and establishment of priorities between the various sections of the work

The scope of work involves developing a COP that will provide technical guidance on the reduction of Cd contamination in cocoa beans in all aspects of production. The development of this COP will help to reduce exposures to Cd and support international trade.

c. Work already undertaken by other international organizations in this field and/or suggested by relevant international intergovernmental bodies.

JECFA has assessed the potential health risk arising from Cd contamination of cocoa and its derivatives in the food supply.

At the 8th session of CCCF (2014) the Codex Committee agreed to establish an EWG to prepare new work on MLs for Cd in chocolates and cocoa derived products.

During the 12th session of the CCCF (2018) the Committee agreed to advance the MLs 0.8 mg/kg and 0.9 mg/kg for chocolate containing or declaring ≥ 50 % to < 70 % for chocolate containing or declaring ≥ 70% total cocoa solids on a dry matter basis respectively, for adoption at step 5/8 by CAC 41. Additionally, the Committee agreed to continue work continue work on the category of chocolate products containing or declaring: (1) < 30 %, (2) ≥30 % to < 50 % and on (3) cocoa powder 100% total cocoa solids on a dry matter basis.

5. **Relevance to Codex Alimentarius Strategic Goals (Plan 2014 – 2019)**

Goal 1: Establish international food standards that address current and emerging food issues

Objective

1.2 Proactively identify emerging issues and Member needs and, where appropriate, develop relevant food standards.

1.2.2 Develop and revise international and regional standards as needed, in response to needs identified by Members and in response to factors that affect food safety, nutrition and fair practices in the food trade.

Goal 2: Ensure the application of risk analysis principles in the development of Codex standards

Objective

2.2 Achieve sustainable access to scientific advice.

2.2.1 Encourage FAO and WHO governing bodies to identify the provision of scientific advice as a high priority and allocate sufficient resources for the FAO/WHO expert advice, in particular from expert bodies such as JECFA, JEMRA, JMPR and JEMNU.

Objective

2.3 Increase scientific input from developing countries.

2.3.1 Encourage developing countries to submit data in response to calls from FAO/WHO expert bodies, through enhanced food safety and nutrition data generation capabilities.

Goal 3: Facilitate the effective participation of all Codex Members

Objective

3.1 Increase the effective participation of developing countries in Codex.

3.1.1 Encourage Members to develop sustainable national institutional arrangements to promote effective contribution to the Codex standard setting processes

Goal 4: Implement effective and efficient work management systems and practices

Objective

4.2 Enhance capacity to arrive at consensus in standards setting process.

4.2.1 Improve the understanding of Codex Members and delegates of the importance of and approach to consensus building of Codex work.

4.2.2 Through networking, training and workshops, improve the skill set of chairs of working groups and committees to achieve consensus

6. Information on the relationship between the proposal and other existing Codex documents

Existing Codex documents:

- Code of Practice for the Prevention and Reduction of Arsenic Contamination in Rice. CAC/RCP 77-2017. Adopted in 2017.
- Code of Practice for the Prevention and Reduction of Ochratoxin A in Cocoa. (CAC/RCP 72-2013)
- Code of Practice for the Prevention and Reduction of Lead Contamination in Foods. CAC/RCP 56-2004

Work in progress (CCCF 13)

- Discussion Paper on the Revision of the Code of Practice for the Prevention and Reduction of Lead Contamination in Foods. CXC 56-2004. CX/CF 19/13/11.

7. Identification of any requirement for and availability of expert scientific advice

Request JECFA to evaluate the possibility of developing a new risk analysis based on tolerable weekly intake of cadmium in chocolate and cocoa derived products (cocoa powder) established on greater availability of data at present.

8. Identification of any need for technical input to the standard from external bodies so that this can be planned for the proposed timeline for completion of the new work

Currently, besides waiting scientific results from validated field researches from this and next year, there is no need for additional technical input from external bodies.

9. Proposed timeline for completion of work

Subject to the approval by the 42nd Session of the Codex Alimentarius Commission in 2019, the following working plan is proposed:

The proposed draft on a Code of practice for the prevention and reduction of cadmium contamination in cocoa beans will be considered at CCCF 14 and CCCF 15 with a view to its completion in 2021 or earlier.

APPENDIX II

PROPOSED CODE OF PRACTICE FOR THE PREVENTION AND REDUCTION OF CADMIUN CONTAMINATION IN COCOA BEANS

(For consideration by CCCF – General comments to provide guidance in the further development of the COP)

FIRST DRAFT OF A CODE OF PRACTICE FOR THE PREVENTION AND REDUCTION OF CADMIUM CONTAMINATION IN COCOA

1. INTRODUCTION

1 The objective of this document is to guide member states of the Codex Alimentarius and the cocoa production industry in the prevention and reduction of cadmium (Cd) contamination in cocoa beans during their production and post-harvest phases. This Code of Practice provides available validated mitigation measures that must be implemented by cocoa producers and post-harvest processors responsible that cocoa that will be used to manufacture chocolates and cocoa products is harmless to humans and will be applied to the cocoa beans commercialized internationally.

2 Cadmium (Cd) is a heavy metal that can reach soil naturally or by anthropogenic activities. It is not found in nature in its pure state. Volcanic activity is the main natural source of Cd release into the atmosphere, and sedimentary rocks and marine phosphates are other natural sources of this metal. Its most common oxidation state is +2, by whose chemical affinity it is associated with iron (Fe), zinc (Zn), lead (Pb), phosphorus (P), magnesium (Mg), calcium, (Ca) and copper (Cu) through its cation exchange capacity. The concentrations of Cd in soil depend mainly on its pH, which controls its solubility and mobility. Most metals in the soil tend to be more available at acidic pH, which increases toxicity for plants. Cd is toxic for biotic beings, persistent in soil and its bioavailability changes in the way it is found in the soil. Cd is absorbed and bioaccumulated by cocoa trees (*Theobroma cacao* L), which in some cases result in unacceptably high levels in cocoa beans, so measures are required to prevent their presence in the soil and reduce their absorption.

3 Greater adsorption of cadmium on the surface of soil particles is desirable, considering that this reduces the mobility of this contaminant in its profile and, consequently, its environmental impact. The concentration of heavy metals (Cd) in soil solution and, consequently, its bioavailability and mobility are mainly controlled by adsorption and desorption reactions on the surface of the soil colloids. Referring to soil factors that affect the accumulation and availability of heavy metals, it is mentioned: pH, texture, organic material, Fe and Mn oxides and hydroxides, Carbonates, Salinity and cation exchange capacity.

2. SCOPE OF APPLICATION

4 The Code is intended to provide country's authorities or food safety authorities; to small, medium or large producers and other relevant organizations guidance on recommended practices to prevent and reduce cadmium contamination in cocoa: Before planting in new plantations, during the production stage until harvest and in the post-harvest stage.

3. DEFINITIONS

Adsorption, Absorption and Desorption: Physical, chemical or exchange adsorption is a concept that refers to the attraction and retention that a body makes on its surface of ions, atoms or molecules that belong to a different body. Absorption is a term that refers to the damping exerted by a body before a radiation that passes through it; to the attraction developed by a solid on a liquid with the intention that its molecules penetrate into its substance; to the ability of a tissue or a cell to receive a material that comes from its outside. Desorption is the process of removing an absorbed or adsorbed substance.

Cation Exchange Capacity (CEC) is a measure of the soil's ability to hold positively charged ions. It is a very important soil property influencing soil structure stability, nutrient availability, soil pH and the soil's reaction to fertilizers and other ameliorants (Hazleton and Murphy 2007). The clay mineral and organic matter components of soil have negatively charged sites on their surfaces which adsorb and hold positively charged ions (cations) by electrostatic force. This electrical charge is critical to the supply of nutrients to plants because many nutrients exist as cations (e.g. magnesium, potassium and calcium).

Drying process: Drying of cocoa beans either under sunlight or in mechanical/solar dryers (or a combination of both) in order to reduce the moisture content to make them stable for storage.

Fermentation: process designed to degrade the pulp and initiate biochemical changes in the cotyledon by enzymes and microorganisms inherent in the environment of the farm.

Soil Amendments: refers to any material added to the soil to improve its physical and chemical properties. The applications of the amendments depend on the characteristics of the soils. The amendments reported in the studies for the elaboration of this COP were: Magnesium carbonate, Vinasse (a by-product of the production of alcohol from sugarcane), Zeolite (minerals that stand out for their ability to hydrate and dehydrate reversibly, adsorbents); Humus (substance composed of certain organic products that come from the decomposition of organic waste by organisms and beneficial microorganisms); charcoal; Calcium sulphate , lime, Cachaza (by-product of sugar cane), Zinc sulphate, Dolomite (calcium carbonate and magnesium), vermicompost, sugar cane, palm kernel cake, phosphate rock, organic matter.

Validation: Obtaining evidence that a control measure or combination of control measures, if properly implemented, is capable of controlling the hazard to a specified outcome. (CAC/RCP 1- 1969), supported by (CAC/GL 69-2008)

Sampling: Procedure used to draw or constitute a sample. Empirical or punctual sampling procedures are sampling procedures, which are not statistical-based procedures that are used to make a decision on the inspected lot. (CAC/GL 50-2004)

4. RECOMMENDED PRACTICES TO PREVENT AND REDUCE CADMIUM CONTAMINATION

BEFORE SOWING - NEW PLANTATIONS

5 As prevention, cocoa plantations should be located in areas where Cd content is not so high, so that agricultural soils should not exceed 1.4 mg/kg of Cd.

6 Use a design of mixed plantations (agroforestry) with several varieties of cocoa and with different types of shade adapted to each ecological environment, instead of monoculture of cocoa without shade.

7 Install plantations in areas far from roads or take measures to prevent the contact of the cacao plantations with the gases emitted by the combustion of vehicles because they may contain cadmium (should be spaced 200 meters apart from the cacao plantation). Likewise, they will be located in areas far from dumps in cities or mining areas.

8 Avoid flooded soils because they could be a source of cadmium.

9 In new plantations, the use of cover crops of perennial legumes should be considered. Cover crops improve soil organic matter and they can protect soil from erosion and reduce the loss of nutrients, improving soil productivity through greater availability of essential nutrients and reducing heavy metal toxicity.

DURING THE PRODUCTION PHASE UNTIL HARVESTING

10 Knowing the sources of cadmium and the distribution of cadmium in the soil is important

11 Soil tests have shown a positive correlation between higher levels of cadmium in soil and in plant tissues and cocoa beans.

12 **Soil characterization analysis laboratories** for cocoa plantations should be accredited; as well as determination methods, also including certified reference material, standards and uncertainty. The type of soil sampling should also be considered because the cadmium content is not homogeneous in the same cocoa farm of a given jurisdiction, in addition, it is very important to carry out soil analyzes with internationally recognized method (i.e. Codex Alimentarius).

13 The determination of soil and irrigation water salinity (Cd chloride salts) is vital since the absorption of cadmium by plants increases with salinity. Therefore, it is important to determine their electrical conductivity of soil and water which should be less than 2mS/cm.

Strategies to immobilize cadmium in the soil

14 Zinc sulphate has a positive effect in reducing cadmium content of the cocoa beans. The application of zinc sulphate is carried out with the balanced fertilization that is carried out annually to the cocoa plantation, according to the requirements of the crop and the soil (characterization analysis).

15 When there is a deficiency of Zn and Mn in the soil, its levels must be increased since cadmium is more likely to enter the plant and the almond of the cocoa.

16 The most effective methods developed so far are liming soil below pH 5.5. It has been shown that increasing the pH by 1 unit reduces the cadmium of the grain by 1/10.

17 Apply liming levels in low doses (2 to 3 MT/ha of dolomite) to gradually increase the pH and incorporate calcium and magnesium essential for the growth of cocoa and precipitate cadmium. Over liming should be avoided.

18 A greater amount of soil organic matter causes a lower absorption of cadmium. The use of organic fertilizers such as treated manure from stabled livestock, compost, etc. increases the organic matter content of the soil and improves its microbiological activity. The application of O.M. in cocoa plantations decreases cadmium grains, reaching very small values of up to 0.08 ppm.

19 Avoid fertilization with phosphate fertilizers and sedimentary rock phosphate because they usually have cadmium as an impurity. For successful cocoa production it is vital to add phosphate fertilizers because tropical soils have very limited native phosphorus content. It is not the type of phosphate fertilizer but the absolute concentration of Cd which should be the basis for application.

20 Use nitrogenous and potassium fertilizers because they normally have very low Cd content and preferably compound fertilizers such as 20-20-20 ($N-P_2O_5-K_2O$, verifying the heavy metal analysis.) Soils well supplied with nutrients are less likely to bioaccumulate cadmium.

21 The application of amendments (CO3 Mg, Vinasse, Zeolite, Humus, charcoal, CaSO4, Cachaza and ZnSO4), depending on the characteristics of the soils, influence the decrease of Cd concentrations in cocoa beans.

22 The application of vinasse, a by-product of the cane industry, as a liquid fertilizer is a source of potassium that promotes the installation of fungi that form mycorrhizas in the roots of the cacao tree, increasing the efficiency of phosphorus nutrition and immobilizing cadmium.

23 Lime and sugarcane cake have the greatest potential to reduce the flow of Cd in the soil profile. Zeolite is another option in soils with high sand content and the apatite in clay-textured soils.

24 Biochar application has shown to reduce the bioavailability of cadmium in cocoa beans. The reduction rates are comparable to liming and have an additive influence on liming. However, activated carbon or biochar is an expensive soil amendment and is not profitable for farmers who grow cocoa.

25 The genotypes identified with low bioaccumulation of cadmium can be used as rootstocks in the production of propagation material to reduce the absorption of cadmium.

POST HARVEST PHASE

26 The draining of the mucilage during 12 hours significantly reduced the content of cadmium in cocoa almonds CCN-51. The quantity of mucilage evacuated from the cocoa beans did not affect the physical or organoleptic quality of the cocoa at the time of the evaluation.

27 Make sure that the grains are not contaminated with smoke, or with gases coming from the dryers or vehicles.

28 During storage, contamination of grains due to spills of fuels, exhaust gases or fumes should be prevented**.**

APPENDIX III

BACKGROUND DOCUMENT

(For information)

INTRODUCTION

1. Cadmium (Cd) is a heavy metal that can reach soil naturally or by anthropogenic activities. It is not found in nature on its pure state. Volcanic activity is the main natural source of Cd release into the atmosphere (U.S.E.P.A cited by Sarabia 2002), with sedimentary rocks and marine phosphates being other natural sources of this metal. Its most common oxidation state is +2, for whose chemical affinity it is associated with iron (Fe), zinc (Zn), lead (Pb), phosphorus (P), magnesium (Mg), calcium, (Ca) and copper (Cu) through its cation exchange capacity. The concentrations of available Cd in soil depend mainly on its pH, which controls its solubility and mobility. Cd is a toxic heavy metal for biotic beings, persistent in the soil and its bioavailability changes on how it is in the soil. Cd is absorbed and bioaccumulated by cocoa (*Theobroma cacao* L) trees, resulting in in some cases in unacceptably high levels in cocoa beans, which requires measures to its uptake from soils.

2. The greater adsorption of Cd on the surface of the soil particles is desirable, bearing in mind that this reduces the mobility of this contaminant in their profile and, consequently, its environmental impact. The concentration of heavy metals (Cd) in the soil solution and, consequently, its bioavailability and mobility are mainly controlled by adsorption and desorption reactions on the surface of the soil colloids (Kabata-Pendias & Pendias, 2001). In reference to soil factors that affect the accumulation and availability of heavy metals, Miliarium (2009) cited by Cargua (2010), mentions: pH, texture, organic matter, Fe and Mn oxides and hydroxides, Carbonates, Salinity and capacity of cation exchange. Singh and Oeste 2001, cited by Carrillo, M (2010) mention that the techniques of immobilization of heavy metals in soils, based essentially on the adsorption phenomena, depend on the nature, concentration and physical-chemical state of the contaminant and soil characteristics. Moreover, Biogeochemical process that control cadmium mobility and availability in soil depend on Precipitation-dissolution, Chelation-dissociation-Complexation, Mineralization-assimilation, Protonation-deprotonation, Metal-organic ligand formation and Redox reaction. Likewise, the relative importance of each process depends on the soil type and its pH, temperature, moisture and organic matter state and is subject to rhizosphere effects.

3. Gutiérrez E. and León C. 2017 report that the German Confederation of Confectioners (BDSI) contacted the Colombian Embassy in Germany to inform about the problem of heavy metal residues in cocoa, especially the existence of Cadmium in imports from Latin America and recommended determining the level of cadmium in crop soils and in cocoa beans; concluding, that if the cadmium levels in the grain exceed the value of 0.5 mg/kg, it is recommended to investigate the origins of cadmium in the crops in order to take the necessary measures.

4. The *Code of Practice Concerning Source Directed Measures to Reduce Contamination of Foods with Chemicals* (CXC 49-2001) reports that the advantage of eliminating or correcting contamination of environmental chemical contaminants (which includes Cd in cocoa) at its source is that the preventive approach is more effective in reducing or eliminating the risk of adverse effects on health and it requires fewer resources to control food and avoids the rejection of food products. Furthermore, it emphasizes that it is important to exercise concern throughout the entire chain of production - processing and distribution since food safety and quality in other aspects cannot be "inspected" at the end of the chain.

5. The Ministerial Resolution of Peru. Ministry of Agriculture and Irrigation. 2018. Through R.M. N° 0451-2018-MINAGRI http://minagri.gob.pe/portal/resoluciones-ministeriales/rm-2018?start=65 approved the document called "Sampling guidelines for the determination of Cd levels in soils, leaves, grains and cocoa products", which aims to establish the reference methods for cadmium sampling in soils, leaves, grains and products derived from cocoa, with a uniform language, according to national and international protocols, which allows the national level to obtain an official baseline, in the different state and private institutions, with the purpose of being able to adequately plan the measures of cadmium mitigation and control in the cocoa areas where it has been verified that there are concentrations in beans above the established in the national and international standards.

This document was prepared in the framework of the implementation of the Country Cooperation Strategy of the Inter-American Institute for Cooperation on Agriculture (EIP-IICA), with the approved opinions of the institutions that form part of the "National Cadmium in Cocoa Technical Group" integrated by the General Agricultural Directorate-DGA, General Directorate of Agrarian Environmental Affairs DGAAA, National Water Authority - ANA, the National Service of Agrarian Health - SENASA and the National Institute of Agrarian Innovation - INIA of the Ministry of Agriculture and Irrigation of Peru, with the participation of the General Directorate of Environmental Health (DIGESA - Ministry of Health of Peru), which specifies the sampling keys of: Cd in soils, leaves of cocoa plantations, cocoa beans, in water of cocoa agricultural areas, products derived from the cocoa (cocoa paste, powder and chocolate), as well as the accreditation of laboratories and methods of analysis by entities nationwide or international.

6. This Ministerial Resolution presents the factors that determine the absorption of cadmium by plants, as it´s seen below:

Table N° 1. Edaphic and crop factors that determine Cd absorption by plants:

Factors	**Effect on the absorption of cadmium by plants**
Edaphic factors Include soil texture and microbiological activity in the list.	
1. pH	The absorption increases when pH decreases (acid soils)
2. Soil salinity	Absorption increases with salinity.
3. Amount of cadmium	Absorption increases with Cd concentration
4. Micronutrients	Zinc and manganese deficiency increase absorption
5. Macronutrients	They can increase or decrease the absorption
6. Temperature	High temperature increases absorption
Crop factors	
7. Species and cultivars	Vegetables>Roots>Cereals>Fruits It reads: Vegetables absorb more than roots, roots absorb more than cereals, and cereals absorb more than fruits.
8. Plant tissue	Leave>grain>fruits and edible roots
9. Leave age	Old leaves>Young leaves

Source: (McLaughlin, Mike. 2016)

Furthermore, soil organic matter has also an influence, higher soil organic matter less absorption; Cocoa in Agroforestry system may have lower Cd values (Gramlich 2017), more work needs to be done to confirm this.

Some strategies for the mitigation of cadmium in cocoa are also suggested

7. To avoid the bioaccumulation of Cd in cocoa beans requires the implementation of different strategies considering the particularities of each agro ecological and production system (organic or conventional or Cocoa in Agroforestry system), so that together they contribute to mitigate the levels of Cd in those plantations that they require it.

According to the available research works it is recommended:

In new plantations:

8. Install plantations on agricultural soils that have less than 1.4 mg/kg of total Cd. (CCME from Canada, 1999; DS 011-2017 MINAM Peru). Moreover: Limits for soil Cd in new plantations would need to be related to soil properties: clay, Fe, and Mn oxides and organic matter, and soil Zn would be important in siting decisions.

9. Use a design of mixed plantations (agroforestry with different varieties of cocoa and with different types of shade (bananas, inga, etc.), adapted to each ecological environment, instead of monoculture of cocoa, without shade) Switzerland comment: Gramlich (2017) showed that there might be a positive effect, however more research is needed on this field. the Association of Exporters ADEX - Peru states that according to evaluation of farms already in production, the agroforestry system works well in the first 2-3 years of planting, as young plants develop better under shade, which helps them to resist better the periods of natural drought in the area. In adult plants the shade favors the proliferation of diseases (moniliasis and witches' broom). Sources: http://www.senasa.gob.pe/senasa/moniliasis-del-cacao/; http://www.agrobanco.com.pe/wp-content/uploads/2017/07/010-f-cacao_CULTIVOS_.pdf

10. Install plantations in areas far from roads or take measures to prevent the contact of the cacao plantations with the gases that emit the combustion of the vehicles because they may contain cadmium. Also, in areas far from dumps in cities or mining areas. In this regard, in large cacao farms, roads must be an important consideration and should be spaced 200 meters apart (SMIARC Technoguide 2014). The US FDA comments that automotive traffic is not a practical source of Cd., and that tires are very low in Cd but very rich in Zn and there is no risk of Cd. It also indicates that during a period between the 1970s and approximately in 2000, some automobile radiators used Cd welding, but they have stopped using Cd. Because gasoline does not contain Cd, the exhaust gases do not cause Cd contamination. The Swiss FSVO emphasizes that from the mining area the contaminated water, the sediment could be the problem away from the mining center since, depending on the size of the emitted particle, the deposition distance may be far from the emitting source.

11. In new plantations, use of perennial legume cover crops should be considered. Cover crops improve soil organic matter. Cover crops can protect soil from erosion and reduce nutrient loss, thereby improving soil productivity through greater availability of essential nutrients and reduction in heavy metal toxicity. (US FDA comment)

In plantations already installed: Strategies to immobilize Cd and decrease its availability in soil:

12. Increase the levels of Zn and Mn in the soil. It has been demonstrated that when there is a deficiency of these micronutrients, Cd is more likely to enter the plant and the cocoa bean. The scientific analysis shows that the imbalance between micronutrients and Cd has a great impact on the absorption of cadmium and the high content of Cd in the cocoa bean. For “Organic” plantations, there are no commercial “Organic” sources of Zn except ground ores, but ores contain Cd at about 1% of the Zn content and should not be used as “Organic” Zn fertilizers. Also, it may be possible that spray application of ZnSO4 or other soluble Zn salts or chelates to the leaves of cocoa trees may be able to inhibit Cd transfer to fruits. Spray Zn has been shown to reduce Cd translocation to several grains in field testing. The ability of spray Zn to inhibit Cd movement to cocoa fruits could be assessed using a multi-year field trial. The action of the Zn spray on leaves is separate from possible effects from the use of Zn fertilizers to inhibit Cd uptake by roots (note again the need to include limestone to counteract acidification resulting from ZnSO4 or other Zn salt applications to soils)

13. Apply liming levels in low doses (3 Mt/ha/year) and preferably dolomite [CaMg $(CO3)_2$] to gradually increase pH and incorporate Ca and Mg that are essential for the growth of cocoa and can precipitate Cd decreasing its bioavailability. This requires further research because there are varieties of cocoa that grow well on slightly acid soils, and could be affected by the increased pH? It is important to recognize that surface application of “lime products” in established cocoa farms cannot increase the pH of the root zone for decades because of the low water solubility of CaCO3 and hence low rate of leaching of alkalinity from surface applied limestone amendments. Several studies of methods to raise the pH of subsurface soil layers have found that combining biodegradable organic matter with lime products allows the metabolism of the organic matter to provide a way to obtain leaching of alkalinity into the subsurface soil (See Brown et al., 1997; Tester et al. 1990; Liu and Hue al. 2001; and Tan et al., 1986). Adjust lime levels based on soil analysis from a reputed soil testing laboratory. Cd in soils cannot be forced to precipitate except in highly calcareous soils. Instead, raising pH causes soil Cd to be adsorbed more strongly by Fe and Mn oxides and organic matter in the soil. Over liming should be avoided. FSVO (Food safety and veterinary Office) from Switzerland mentions that No field research in existing plantation is published to show dosage, etc., and its effect on Cd uptake and Cd bean concentration.

14. A field experiment, lasting 18 months, was performed to assess the effectiveness of liming on pH, bioavailability of Cd in soils and its uptake in cacao tissues concluded that remediation by liming of cacao soils contaminated with Cd to reduce its uptake appears feasible, based on the results of laboratory and field trials in Trinidad and Tobago (Gideon Ramtahal et al. 2018).

15. Increase the content of organic matter in the soil and improve its microbiological activity using fertilizers or organic fertilizers such as treated manures from feedlots, stabled cattle in farms, compost, bokashi, among others**.** For this action it is important to previously know the contents of cadmium in the inputs to be used. Table N° 2 shows estimated contributions, minimum and maximum range of Cd added to agricultural soils by different sources (mg/kg) and table N ° 3 exhibits concentration of cadmium in rocks. The FDA from USA mentions that if there were other data available such as median or average, these would provide additional information about the influence of management practices on Cd concentrations.

Table N° 2: Estimated contributions of heavy metals added to agricultural soils by different sources (mg/ kg), range (minimum to maximum)

Heavy metals	Phosphate fertilizers	Nitrogen Fertilizers	Plant-protection products	Manure	Sludge from sewage
Cd	**0.1 - 170**	**0.05 - 8.5**	**1.38 - 1.94**	**0.3 - 0.8**	**2 - 1500**

Source: Sánchez, 2003; Mico, 2005; Peris, 2006; Delgado, 2008. Cited by Rueda, Rodriguez y Madriñan, 2011

Table N° 3: Cadmium concentration on rocks

Type of rock	Range mg/kg	Average mg/kg
Igneous rocks		
Rhyolites	0.03 – 0.57	0.230
Granites	0.01 – 1.60	0.200
Basalt	0.01 – 1.60	0.130
Sedimentary rocks		
Schists and clays	0.017 - 11	-
Black schists	0.30 – 219	
Sandstones and conglomerates,	0.019 – 0.4	-
Carbonates	0.007 – 12	0.065
Phosphorites	**<10 - 980**	**-**
Coal	0.01-300	-
Sulphur mineral deposits		
Sphalerite (SZn)	0.02 – 0.4 (<5%)	-
Galena (SPb)	<0.5%	
Tetrahedrite, Tennantite (CuSZn)	0.24%	
Metacinnabar (HgS)	11.70	

Source: Alloway, 1995

16. Regarding microbiological activity, the effect of microorganisms in the decrease of cadmium intake in cocoa is well documented: Bravo et al (2018) and Revoredo, A. and Hurtado, J. (2018) who have shown that microbial inoculum are effective in cocoa crops.

17. Avoid fertilization with phosphate fertilizers and sedimentary rock phosphorus because they usually have as impurity the cadmium being lower in phosphorus's of igneous origin**.** Smolders (2017) expresses that for successful cacao production it is vital to add phosphate fertilizers because tropical soils have very limited native phosphorus content. It is not the type of phosphate fertilizer but the absolute Cd concentration that should be the basis for guidance. These farms are reported to have very low levels of plant available P based on published surveys of soil P fertility, so P fertilizers may be useful to increase growth and hence growth dilution of Cd in the plants. The EU, US and many other nations have limits on Cd in P fertilizers including rock phosphates that may be sold commercially. Smolders (2017) summarizes the current best advice about appropriate limits for Cd in P fertilizer products. One major problem in the Latin American and Caribbean nations producing cocoa is the failure to verify Cd in fertilizer products and to tightly regulate Cd in fertilizers. Such regulations need to be developed and enforced in cocoa fertilizers.

18. Use nitrogen and potassium fertilizers because they usually have very low cadmium content and preferably compound fertilizers such as 20-20-20 (N-P_20_5 and K_20), verifying the heavy metal analysis. It is demonstrated that in well-supplied soils the chances of bioaccumulation of cadmium are lower. It must be emphasized that nitrogen and potassium fertilizers should not be used in organic cocoa plantations.

19. Preparation and use of activated carbon using different types of materials, preferably local (residual biomass or stubble) can be applied to decrease the availability of Cd in soil by the adsorption mechanism. However, activated carbon or biochar are expensive soil amendments and not likely economic for cocoa farms, especially the small ones. It should be kept in mind that activated carbon should not be used in organic cocoa plantations.

20. Apply vinasse (by product of the cane industry), a rich liquid fertilizer as a source of potassium, it also can promote the installation of fungi that form mycorrhizas in the roots of the cacao tree and increase the efficiency in the nutrition of phosphorus in this crop, give resistance to drought, protection against diseases, and immobilization of cadmium.

21. Use preferably native mycorrhizae of the area and other bio remediators that "capture" the cadmium present in soil and so that making it not available for cocoa**.**

Phyto extraction of heavy metals (Cd).

22. It is a technique that involves planting plants (trees, shrubs, herbaceous, cover crops) in soils contaminated with heavy metals in order to extract them through the root system and transferred to the leaf mass, which is harvested and incinerated (450° C) to turn it into ashes and then decide whether to go to confinement or to an analytical or industrial chemistry laboratory so that they can reuse these metals. It is worth mentioning that the application of this technique requires having an implemented biosecurity system to prevent foliage from being used for food or feed. Chaney, R.L y Baklanov. 2017 report that unfortunately, plant species with demonstrated very high Cd accumulation are not adapted to tropical environments. And growing another crop under the cocoa trees and harvesting the above ground biomass annually to remove the Cd would be very difficult in cocoa plantations.

23. Agronomic management of the cocoa crop

    In the efficient agronomic management of the crop it is important: the pruning, the number of plants per hectare, the shade systems, the humidity regime in the soil, the application of fertilizers and amendments, the doses and moments of performing these tasks, which allow that the cocoa metabolism be adequate and there is less likelihood that cadmium enters the roots because this metal normally bioaccumulates in greater quantities in low fertility, sandy soils, poor in organic matter, low concentrations of zinc and manganese, strongly acids (pH <5.5) and with poor handling.

24. When the physiology of cocoa is adequate, the production and functioning of enzymes will favor their normal metabolic processes, decreasing the bioaccumulation of cadmium in cocoa beans, since there are self-defense mechanisms of plants against contaminants that are activated when plants are healthy and well nourished. USA comment: There are no known special physiological activities of normal well growing plants that reduce Cd accumulation. Stunting of growth, especially by excessive soil acidity, causes higher Cd accumulation. Table 4 below presents a list of conditions that generate bioaccumulation of Cd in cocoa beans and their proposed mitigation measures:

Table 4.- Conditions of soil and water that favor Cd bioaccumulation in cocoa beans.

Conditions of soil and water that generate cadmium bioaccumulation in cocoa beans USA indicates that it is very unlikely that saline irrigation waters are a problem in cocoa production and Cd. Providing a warning about high levels of chloride in irrigation water, fertilizers, and other soil amendments is appropriate. And it is specifically soil chloride, not salinity that causes higher Cd accumulation in all plant species. Also, advice about soil pH should be more specific. Surveys of soil properties in cocoa plantations in several nations reported soil pH as low as 4.5 which strongly promoted Cd accumulation (see publication list below). Soils in the rooting zone should be limed to reach a pH of 6.5 if cocoa Cd levels need to be reduced. And if the soil has naturally high Cd levels, soils should be made calcareous to minimize Cd accumulation, or other crops should be grown	**Proposed mitigation measures**
Soils of low natural fertility	Fertilize the soil with good nutrient content
Low content of organic matter in the soil	Increase organic matter (> 4% MOS)
Low concentration of Zn and Mn	Incorporation of Zn and Mn
Sandy soils	Avoid sowing in sandy soils, preferably use loam to clayey soils
Saline waters (2 mS/cm) with high chloride content. In the unit mentioned S stands for Siemens	Treat water to lower its salinity and decrease chlorides
Strongly acid soils	Liming the soil to moderately acidic to neutral levels

25. **Planting areas:** As prevention, the planting of cocoa trees should be in areas where there is no high Cd content, so agricultural soils should not have more than 1.4 mg/kg of Cd (CCME of Canada, 1999; DS 011-2017 MINAM Peru).

DEFINITIONS

26. **Adsorption, Absorption and Desorption**: Physical, chemical or exchange adsorption is a concept that refers to the attraction and retention that a body makes on its surface of ions, atoms or molecules that belong to a different body. Absorption is a term that refers to the damping exerted by a body before a radiation that passes through it; to the attraction developed by a solid on a liquid with the intention that its molecules penetrate into its substance; to the ability of a tissue or a cell to receive a material that comes from its outside. Desorption is the process of removing an absorbed or adsorbed substance.

27. **Cation Exchange Capacity (CEC)** is a measure of the soil's ability to hold positively charged ions. It is a very important soil property influencing soil structure stability, nutrient availability, soil pH and the soil's reaction to fertilizers and other ameliorants (Hazleton and Murphy 2007). The clay mineral and organic matter components of soil have negatively charged sites on their surfaces which adsorb and hold positively charged ions (cations) by electrostatic force. This electrical charge is critical to the supply of nutrients to plants because many nutrients exist as cations (e.g. magnesium, potassium and calcium).

28. **Drying process:** Drying of cocoa beans either under sunlight or in mechanical/solar dryers (or a combination of both) in order to reduce the moisture content to make them stable for storage.

29. **Fermentation:** process designed to degrade the pulp and initiate biochemical changes in the cotyledon by enzymes and microorganisms inherent in the environment of the farm.

30. **Soil Amendments:** refers to any material added to the soil to improve its physical and chemical properties. The applications of the amendments depend on the characteristics of the soils. The amendments reported in the studies for the elaboration of this COP were: Magnesium carbonate, Vinasse (a by-product of the production of alcohol from sugarcane), Zeolite (minerals that stand out for their ability to hydrate and dehydrate reversibly, adsorbents); Humus (substance composed of certain organic products that come from the decomposition of organic waste by organisms and beneficial microorganisms); biochar; Calcium sulphate , lime, Cachaza (by-product of sugar cane, part of the waste left after processing), Zinc sulphate, Dolomite (calcium carbonate and magnesium), vermicompost, sugar cane, palm kernel cake, phosphate rock, organic matter.

31. **Validation:** Obtaining evidence that a control measure or combination of control measures, if properly implemented, is capable of controlling the hazard to a specified outcome. (CAC/RCP 1- 1969), supported by (CAC/GL 69-2008).

32. **Sampling:** Procedure used to draw or constitute a sample. Empirical or punctual sampling procedures are sampling procedures, which are not statistical-based procedures that are used to make a decision on the inspected lot. (CAC/GL 50-2004)

FIELD PRODUCTION MEASURES TO PREVENT AND REDUCE CADMIUM CONTAMINATION

33. Knowing the sources of cadmium and distribution of cadmium in the soil are also important. Several soil-plant surveys of Cd in Latin American countries have found substantial Cd enrichment of some of the national soils used in cocoa production. The somewhat higher Cd in topsoil than subsurface soils could arise from both application of fertilizers (particularly phosphate products), or aerosol emissions from industrial sources. Natural soil metal enrichment can arise from mineralization (both Zn and Cd) are enriched near mines of Zn, Cu and Pb (Cd:Zn ratio typically 0.005 to 0.01 µg Cd/µg Zn). Marine shale rock can yield Cd with high Cd:Zn ratio which has greater plant availability than the Zn ore type of contamination. And several areas in Latin America have been found to have significant and even extreme local Cd contamination from these marine shale sources (Garrett et al., 2008); some of the Jamaican soils have higher Cd than Zn, an extremely rare event. Where Cd is above background levels (say 0.2-0.5 mg Cd/kg dry soil), other elements (Zn) help clarify the source. Soils developed from phosphate deposits are rich in P, Cd and Zn with typical Cd:Zn ratio of 0.1. Thus at least the Zn and P levels of suspect high Cd soils should be measured to help clarify the source. (Garrett, R.G., A.R.D. Porter, P.A. Hunt and G.C. Lalor. 2008).

34. Soil analyzes should be a requirement for current and new cocoa farmers to identify soil and water with lower levels of cadmium. Those areas with higher levels should be designated for other types of cash crops, such as coffee or those plants with lower cadmium absorption. The Association of Exporters of Peru - ADEX states that coffee and cocoa are produced in different ecological levels, so it cannot be suggested to change cocoa plantations for coffee. Quality coffee grows above 1000 meters above sea level - http://www.minagri.gob.pe/portal/especial-iv-cenagro/24-sector-agrario/cafe/204-cafes-especiales-en-el-peru and cocoa between 300 and 900 meters above sea level - https://www.sierraexportadora.gob.pe/programas/cacao/que-significa.php. The FSVO of Switzerland states that soil sampling should also be addressed, since the contents of Cd are not homogeneous. In addition, factors such as pH or soil organic matter should also be considered. Davila, C. b (2018) for the characterization of the soils contemplated in their analysis: pH, electrical conductivity, calcium carbonate, organic matter, phosphorus, potassium, mechanical analysis (sand, silt, clay), textural class, exchange of cations, changeable cations (Ca, Mg, K, Na, Al + H), sum of cations, sum of bases, saturation of bases).

35. For the analysis of Cd, several methods not included in CODEX STAN 228/2001 may be used, but the selected method should meet the performance criteria required for the maximum levels above 0.1 mg / kg established in the Commission's Procedural Manual of Codex Alimentarius that are the same as those established in the European Union regulation (EFSA, 2009) for limit of detection (LOD), limit of quantification (LOQ) and precision. Recovery must have a range of 80% 110%.

36. Use the results of the soil tests to determine if there is a need to apply fertilizers or soil amendments to ensure adequate soil pH and plant nutrition to avoid plant stress, especially during the development stage of the seeds, unless the producer can prove that his proposed action plan reduces the risk to allowable levels. It can be said that cocoa is a plant that thrives in a wide variety of soil types. van Vliet and Giller 2017, reviewing Mineral Nutrition of Cocoa establishes that among production constraints met by cocoa farmers is nutrient limitation. In their review they compile current knowledge on nutrient cycling in cocoa production systems, nutrient requirement of cocoa, and yield response to fertilizer application in relation to factors such as management, climatic, and soil conditions.

37. Soils with a higher cation exchange capacity (59.0-60.6 meq/100g) would have a greater capacity to fix metals (Cargua, J. et al., 2010). USA comments that "CEC 59.0 to 60.6 meq/100 g" does not appear to be correct. Typical CEC of cocoa soils is <15 in the published literature. Sandy soils have low CEC, some as low a <5. Also, it is not CEC per se that reduces Cd Phyto availability, it is the surface area of Fe and Mn oxides and chelation ability of organic matter which adsorbs Cd and reduce Phyto availability. Clays in higher CEC soils are usually coated with Fe and Mn hydrous oxides, so clays are correlated with Cd adsorption.

38. Cargua et al 2010 cites Miliarium (2009) who also observed that clay tends to adsorb heavy metals that are retained in their exchange positions and that; on the contrary, sandy soils lack the capacity to fix heavy metals. which pass quickly to the subsoil and can contaminate groundwater levels.

39. Before harvesting, make sure that all the equipment, which will be used for harvesting, drying, cleaning and storing the crops, is in good working order and the waste, grains and dust are cleaned as much as possible. A breakdown of the equipment during this critical period can cause losses in the quality of the grains and increases the appearance of cadmium**.** Make sure that the equipment necessary for moisture content measurements is available and calibrated.

40. Harvest: avoid harvesting immature cacao fruits, since they have a solid pulp without mucilage and the cocoa beans are difficult to separate from the pod and do not ferment properly.

41. Fertilization: The use of long-term phosphate fertilizers causes high levels of Cd in the arable layers of the soil (IPCS 2010), although USA FDA comments that it is important to maintain adequate P fertility so that trees are not stunted by low P and accumulate high Cd in the stunted trees, it is better to advice use of P fertilizers with limits on Cd in the products. Ensuring regulations governing the sampling, monitoring and enforcement of P-fertilizer limits is what is needed. Such limits may also be needed on Zn fertilizer products because some byproduct-derived Zn fertilizer products contain much higher Cd than any P fertilizer.

42. Cost-effectiveness of Cd mitigation measures: Treatment of soil contaminated with metals by immobilization with chemical amendments such as dolomite, **limestone** can provide less expensive and viable alternatives to reduce the availability of metals (Trakal et al., 2011). Furthermore, personal communication from International Researchers participating in the Forum (MINAGRI-IICA 2018) emphasized that the use of said chemical amendments increases the production of the cocoa crop. Production is increased because nutrient limitation is reduced.

43. The Guide for Phytosanitary Management and Safety in the cocoa farm (MINAGRI-SENASA-IICA, 2017), mentions that the management of the cocoa crop with an agroforestry system reduces the concentration of cadmium. On the other hand, it allows providing differentiated environmental services to society, constitutes an environmental alternative and contributes to the mitigation of cadmium. See "Use of timber and non-timber forest resources of the cocoa agroforestry system" (Theobroma cacao L.) https://www.academia.edu/28727375/USO_DE_RECURSOS_FORESTALES_MADERABLES_Y_NO_MADERABLES_DEL_SISTEMA_AGROFORESTAL_CACAO_Theobroma_cacao_L._USE_OF_TIMBER_AND_NON-TIMBER_FOREST_RESOURCES_IN_THE_CACAO_Theobroma_cacao_L._AGROFORESTRY_SYSTEM

Validated measures applied in producer countries and obtained with support from industrialized countries

44. Colombia

The National Codex Alimentarius Committee of Colombia, in response to circular letter CL 2018/73-CF, forwarded the requested information with the following details:

Summary of the demonstrated measure: Study of the microbial diversity associated with cocoa soil with presence of cadmium (Cd) and evaluation of its bioremediatory potential.

Description of the measure: Characterize the populations associated with cocoa soils with the presence of Cd and evaluate the bioremediation potential of some isolated microorganisms, both at laboratory level and in greenhouse bioassays. Cultivation-dependent techniques (isolation, phenotypic and genotypic characterization and analysis of the potential of biological activity) and culture-independent techniques (last generation sequencing techniques [NGS] and analysis of marker genes (RNAr 16S) that are complementary to each other and allow, on the one hand, to study the structural diversity of these microbial communities and on the other, allow to perform a bioprospecting of the isolated organisms for the characterization of the microorganisms involved, microbiology methods, dependent culture and molecular techniques will be used to elucidate the identity and characteristics of the spices involved in the process.

Location of the study: "Finca (Spanish name for cocoa farm) pH soil acid / soil high total [Cd]. Finca pH soil acid y soil low total Cd. "Finca pH soil neutral / basic and soil high total Cd. Finca pH soil neutral/basic and soil low total Cd.

Estate: 1 Latitude: 06-55-24,3 Longitude 073-28-40,5

Estate 2: Latitude: 06-53-10.2 Longitude 073-23-13.8

Estate 3: Latitude: 06-54-143 Longitude 073-22-156

Farm 4: Latitude: 06-54-494 Longitude 073-44,1-178

The study began in 2015 and will end in 2019

Study area and plot size: Total trees 3,200, approximately 3.5 Has.

The varieties of cocoa under study are: ISC95, ISC60-39, CCN51, new varieties (SYS).

Planting time: Farm 1: 15-20 years, Farm 2: 40-50 years, Farm 3: 5-10 years, Farm 4: 6-80 years.

Sampling date with respect to the application of the measure: Semester I, 2017. 3 samplings per farm, spaced approximately every 2 months.

Number of samples taken: A total of 12 samples (3 samples per farm). Each composite sample was formed from subsamples (n = 18), selecting at random during the Zigzag run, cocoa trees with good phytosanitary status, cleaning the surface of the land (under the tree's leak) and introducing a hole to the indicated depth. For the collection and final handling of the samples, the NTC 4113-6 (2) was followed. Each composite sample (2 Kg).

Cd concentrations in the samples: The concentration of Cadmium in soil is variable, samples were found with amounts of 44 mg / 100 g of sample, up to 0.01 mg / 100 g. This is the before. The after has not yet developed. USA mentions that the listed concentrations are confusing. 44 mg/100 g is 440 ppm which would be very highly contaminated; but “up to 0.01 mg/100 g” is equal to 0.1 mg/kg which would be a relatively low Cd soil concentration.

45. **Colombia, Gutiérrez E. y León C. 2017:**

Study "Evaluation of amendments in order to solve the problems of Cd concentrations in soil and dry grain". Year 2010 to 2012- Santander: The following details are defined:

Kelley directives were followed for the classification of soil contaminated with cadmium; which values in mg/kg dry soil vary from:

Typical values for uncontaminated soils	Light contamination	Contamination	High contaminatio n	Contamination unusually high
0 – 1	**3 – 5**	**5 - 10**	**10 - 20**	**> 20** These suggested ranges of Cd in different soil contamination classes are confusing. Soils with over 1.0 mg Cd/kg are already unusual. Background soils are usually defined as 0-0.7 by some authors. And as noted above, when soils are rich in Cd but not in Zn, that soil Cd comprises much higher risk than when usual soil Cd/Zn ratios occur (Garrett et al, 2008; Chaney et al, 2009).

595 samples were taken in 59 municipalities within eleven (11) provinces.

In the soil samples the following analyzes were carried out: Chemical: Complete + minor elements less from 0 to 30 cm., Physical: Apparent and real density, and texture by Bouyucos at 0 -30 cm, Total Cadmium and Cadmium available at 0 -30 cm and total and available Cadmium at 30-60 cm.

In the sampling of pods, the following were analyzed: Dry cocoa bean with husk - almond and dry cocoa bean without husk – cocoa husk.

Service laboratory - Area: Analytical chemistry were used: AA spectrophotometers (240FS / 280FS) and Spectrophotometer (ICP-OES) ICAP 6500 -Thermo Scientific.

The results obtained were

Baseline defined by the total concentration of Cd, present in soils of the cocoa areas: Of the 207 samples analyzed, highly variable Cd levels were found in the different sampled areas (between 0-1 mg / kg to > 10 mg / kg).

The cocoa bean samples for which there is a maximum allowed limit of cadmium of 0.5 mg / kg: 175 (84.5%) were below this legal limit and 32 (15.4%) exceeded it. In the latter areas, a highly significant correlation (r = 0.652 and p> 0.001) was found between the cadmium content of the grain with respect to cadmium available in the soil.

In an evaluation of the nutritional status of the cocoa soils, it was found:

The average value of pH in the cocoa municipalities is 5.6 considered moderately acidic, where 40% of the soils have high interchangeable aluminum contents

76% of the soils have low O.M content

49% of cocoa soils have phosphorus deficiencies, a response commonly found in more than 70% of the country's soils due to the acidity of the soil.

With reference to the bases of soil potassium, calcium, magnesium and their relationship, we find that 85% of cocoa soils have potassium deficiency, 16% of soils have low Mg content and 65% of soils have an adequate ratio Ca/Mg.

The effects of three treatments (compost and/or biofertilizers of ECOCACAO), organic biofertilizer (vermicompost and/or poultry manure) + mycorrhizae + dolomitic lime, and a combination of dolomitic lime, phosphoric source, potassium source, mycorrhizal soil and organic fertilizer were evaluated. It was carried out in six farms in an experimental plot of approximately 1200 m2 (144 cocoa trees).

The levels of application of each one of the sources of fertilization are dolomitic lime (1.5 - 2.5 kg/plant), Potassium (300-350 gr/plant), Phosphorus (35-50 gr/plant) and Organic matter (350 gr - 1 kg/plant) and mycorrhized soil (20: 1).

The analysis of variance does not show statistical differences in the properties of the soil due to the effect of the remediation treatments that have been applied to the soil and do not show changes in soil properties.

For the presence of total and available cadmium in soils, in cocoa almond and foliar tissue (leaves), the analysis of variance does not identify differences among the treatments in the municipalities evaluated.

46. **Ecuador**

SENESCYT (2011). Project: Recovery of contaminated soils due to the presence of cadmium in the most polluted areas of the provinces of Manabí, Santa Elena and El Oro. "The following details are pointed out:

The study was conducted from July 2012 to December 2014

The samples were taken in El Oro Province, Pasaje locality and in the Rio Grande farm; Peninsula Province of Santa Elena, Cerecita locality, La Mejor farm and in the Manabí province, locality Canuto and “Experimental” farm. The experimental plots contained 20 plants each, of which six central plants were identified to monitor the contents of Cd in time.

Eight amendments were evaluated: Co3Mg, Vinasse, Zeolite, Humus, charcoal, CaSO4, Cachaza and ZnSO4; applied in two doses in the varieties of Cacao CCN51 in the provinces of Santa Elena and El Oro and the National variety of cocoa in the province of Manabí.

The application of the amendments was made depending on the characteristics of the soils:

Results obtained

In Santa Elena Peninsula, El Oro and Manabí, the soil responded to the application of 1 MT/ha and 2 TM/Ha of the eight amendments, since it was possible to reduce the **Cd contents** significantly in the four depths evaluated (0 - 5cm., 6 - 10 cm., 11 - 15 cm., and 16 - 20 cm.) compared to the contents of the control (treatment without amendment)

In the soil of Santa Elena Peninsula, the application of the dose of 1 MT/ha of Humus and Calcium Sulphate decreased the Cd contents of 1.76 mg/kg present in the control to 1.10 mg/kg of Cd in the first 5 cm of the ground. With the application of 2 TM/Ha, it was reduced from 1.76 mg/kg in the control to 1.02 mg / kg when using charcoal.

In general, it was observed that all the amendments applied to the soil influenced the decrease in Cd concentrations in cocoa beans. At the end of the study it was determined that calcium sulfate and cachaza managed to reduce in 46 and 44%, respectively, the concentrations of cadmium in cocoa almonds in the Santa Elena Peninsula

In El Oro, when 1 MT/ha of vinasse was applied, the contents of cadmium in the soil are reduced from 4.87 mg / kg to 2.38 mg/kg and when 2 MT/ha was applied, the zeolite lowers these contents to 2. 29 mg/kg.

In the case of El Oro, the dolomite and vinasse amendments lowered the contents of cadmium in almonds of cocoa by 48 and 45%, respectively.

In Manabí the control presented 1.35 mg/kg of Cd in the first 5 cm of the soil, gradually decreasing as the depth increases. With 1 MT/ha. calcium carbonate was able to lower the contents to 0.57 mg/kg and with the high dose 200 kg/ha of zinc sulfate the contents were reduced to 0.59 mg/kg.

Finally, in Manabí all the amendments with the exception of magnesium carbonate had a similar behavior reducing by 30%, the contents of cadmium in cocoa beans.

47. In Brazil

Carrillo, M., et al. 2010. Efeito of different conditioners na mobilidade of cádmio em dois latossolos brasileiros. The details of the study are:

The objective of the study was to evaluate the movement of Cd in the profile of the soil affected by the addition of three organic conditioners (vermicompost, cake of sugarcane and palm kernel cake and three minerals (limestone, apatite and zeolite), in two Brazilian Oxisols ("Tiro de Guerra" and Tres Marías) with clay and medium texture, respectively, to know the retention of Cd in soils, using the leaching column method.

Results

Lime and sugarcane cake have greater potential to reduce the flow of Cd in the soil profile.

Alternatively, another option is zeolite, in soils with high sand content and apatite, in clay-textured soils.

48. In Belgium

The International Confectionery Association based in Brussels in its comments in response to Circular Letter CL 2018/73-CF on Research in mitigation refers to a study conducted from 2014 to 2017 at the Cocoa Research Center, University of the West Indies and supported by the Joint Research Fund of the ECA / CAOBISCO / FCC, which leads to a better understanding of the different factors that affect the availability of the Cd and the absorption of the metal. Three possible solutions for mitigation have been proposed:

Grafting plants with rootstocks with low cadmium content.

Obtain new varieties that are not as prone to the absorption of cadmium

Modify soils to reduce the absorption of cadmium by plants.

On the other hand, in the summary of the measures demonstrated, it specifies:

Soil analyzes have shown a positive correlation between the highest levels of cadmium in the soil and in the tissues of the plants and cocoa beans.

There also seems to be a high correlation between the absorption of cadmium by cocoa plants and the acidity of the soil. A high acidity in the soil generally corresponds to a higher level of cadmium accumulation.

There seems to be some correlation between the use of phosphate fertilizers and the absorption of cadmium by the cocoa plant.

Cocoa beans from different growing areas in the same country and in different countries have a wide range of cadmium levels.

Citing as remediation for the measures mentioned above, the following:

Soil analyzes should be a requirement for all new cocoa farmers to identify the soils with the lowest levels of cadmium. Areas with high levels of cadmium should be assigned to other types of commercial crops such as coffee or those plants with lower cadmium absorption**.** The use of phosphate fertilizers should be minimized.

49. In Belgium

FOODDRINK EUROPE based in Brussels

In its summary of the measures shown, the following were specified:

The cadmium contamination of cocoa beans depends to a large extent on the content of cadmium in the soil and its bioavailability.

The bioavailability of cadmium depends on:

- Soil pH

- Content of organic matter.

- Deficiency of specific nutrients.

- Cl^- ions on the ground

The work of the Cocoa Research Center supported by the Joint Research Fund of the FCC / CEA / CAOBISCO is focusing on the management of all the mentioned parameters, except the Cl^- Ions in the soil.

The most effective methods developed so far are the liming of soils below pH 5.5.

It has been shown that increasing the pH by 1 unit reduces the cadmium of the grain by 1/10

The application of biochar has also been shown to reduce the bioavailability of cadmium in cocoa beans. The reduction rates are comparable to liming and have an additive influence on liming.

The cadmium contamination of cocoa beans is also a function of the cocoa variety. In the **CRC study** mentioned above, 10 genotypes with low bioaccumulation of Cd have been identified that can reduce the Cd levels in grains by 7 times.

In addition to the previous measures that reduce the contamination of the grain with cadmium, due to the natural geological contamination of the cocoa, the contamination of the soils can come from:

- Sources of contaminated fertilizers.

- Contaminated irrigation water.

- Contaminated floodwater.

Any additional contamination should be avoided by careful selection of fertilizers, irrigation water and flood prevention and cites as a description of the measure:

Handling soil pH by liming.

As a first step, the following soil parameters should be recorded: total cadmium, bioavailability of cadmium, soil pH, physical composition of the soil, organic matter content and cation exchange capacity with the support of certified laboratories. On the basis of this requirement, the liming can be calculated and, depending on its effectiveness, the liming rates can be adjusted.

In the second phase of the project, field trials are being carried out to further determine the effectiveness of the use of lime and biochar, including the frequency of application and application methodologies. Additional parameters are being investigated, such as nutrient availability and productivity.

The genotypes with low bioaccumulation of cadmium identified in our study (Lewis et al., 2018) can be used as rootstocks in the production of propagation material to reduce the absorption of cadmium.

Additional studies are being conducted in hydroponic experiments to understand whether the differences observed by Lewis et al 2008 are due to differences in root morphology or genetics. Bio accumulators with low cadmium content are being tested as rootstocks because of their effectiveness.

50. Peru

Garcia, J. and Garcia L. 2018. Genetic selection against the accumulation of cadmium.

In order to study the kinetics of the accumulation of heavy metals, cadmium (Cd) and lead (Pb) in different cocoa clones seeking to identify those with reduced accumulation in vegetative and reproductive organs, this trial was carried out during June-November, 2017 at the Tulumayo Station, Tingo María.

The genetic material (clones) of the selected cocoa was the result of a process of individual selection-hybridization-genealogical selection, carried out by the Cocoa Genetic Improvement Program initiated in 1995 and directed by Dr. Luis García, principal professor of the National Agrarian University of La Selva - Tingo María, Huánuco, Peru.

With the exception of clone C-60 (selection in the farmer's field) of San Martin; the other clones are identified and have their respective genealogies and were already characterized morpho agronomically by Dr. Luis García, (2012) in the Catalog of Cocoa Crops of Peru.

In the following table their corresponding genealogies are presented. Clones S-8 and S-12 are complete siblings (biclonal hybrids) of the IMC-67 x EET-228 crossing of the Forastero Alto Amazónico x (National x unknown) genetic groups. The clone S-23 is a biclonal hybrid of the cross between 2 clones of Forasteros Alto Amazónicos, one from Iquitos and the other from Cusco. The clone S-28 is a biclonal hybrid of the crossing between a Trinitarian clone with a clone of Stranger of the High Amazonía of Ucayali.

Number	CODE	GENEALOGY
1	**S-8**	**(IMC-67 x EET-228)**
2	**S-12**	**(IMC-67 x EET-228)**
3	**S-23**	**(IMC-67 x U-68)**
4	**S-28**	**(ICS-1 x SCA-6)**
5	**S-60**	**SELECTION IN AGRICULTURAL FIELD**

Dr. Garcia, L. researcher, states that the scientific article is in preparation and will be submitted for publication in English to 2 magazines, one Brazilian and the other from England. Likewise, in relation to other complementary or more in-depth studies, it expresses that they are in mind through the team of researchers of the UNAS, but it could not be executed if funding is not obtained before.

51. Peru

Dávila, C. 2018. a. Technological package to decrease the content of cadmium in cocoa beans.

The Cooperativa Agroindustrial Cacao Alto Huallaga (CAICAH) made the diagnosis of Cd of the cocoa beans of its associates; determining an average content of 0.84 ppm.

To date, CAICAH has been developing a series of technologies at the field level to reduce the cadmium content in cocoa beans. After 2 years of research we can mention the most efficient technologies for this purpose:

Soil liming (pH less than 5.5). In acidic soils, Cd is more available and can be easily absorbed by plants. Liming provides calcium to the soil solution, which is antagonistic to Cd; it also allows increasing the pH, increasing the negative charges of the soil and therefore facilitates the adsorption and complexation of cadmium in the soil, making it not available for plants. Floating materials that can be used to increase soil pH can be: agricultural lime [Ca $(OH)_2$, SiO_2, CaSO4], slaked lime [Ca $(OH)_2$], dolomite [Ca Mg (CO3) $_2$]. The project area of CAICAH evaluated the effect of dolomite on the decrease of cadmium in cocoa beans, three treatments were used (1.80 kg of dolomite/plant, 2.70 kg of dolomite/plant and 3.60 kg of dolomite/Plant, obtaining the following results after one year 0.52 ppm, 0.47 ppm and 0.45 ppm, respectively, of cadmium in cocoa bean, without peel, using the Official method 999.11-AOAC **Conclusion**: The application of dolomite in cocoa plantations decreases the content of cadmium in the beans, positive effect.

Application of organic matter (compost, poultry manure, humus, manure, etc.)

The organic matter thanks to its functional groups (OH, COOH, NH2, CONH2, CO, quinones, etc.) of the humic substances, reacts with Cd, giving rise to complexes of Cd or chelates; in this way the Cd can be in position not available for plants. The organic matter provides carbon to the microorganisms of the soil, fact that allows increasing the microbial population and its enzymatic activity; soil microorganisms allow: precipitate, sequester, volatilize and complex the cadmium, favoring the adsorption of Cd in the soil. You can use compost, poultry manure, humus, manure, etc.; the quantities of these materials to be applied per Ha. will depend on the organic matter content (O. M.) of the soil, indicated in the characterization analysis; in general, the soil should be handled with an average level of O.M. from 3 to 4%, to preserve the physical, chemical and biological characteristics. CAICAH evaluated the effect of compost and manure on the reduction of Cd in cocoa beans. The following treatments were used: Compost - dose of 27 kg/plant or 30.00 MT/ha, 54 kg/plant or 60.00 MT/ha and 81 kg/plant or 90.00 MT/ ha; poultry manure - dose of 27 kg/plant or 30.00 MT/ha, 54 kg/plant or 60.00 MT/ha and 81 kg/plant or 90.00 MT/ha and Control - dose of 00.00 kg / plant or 0.00 MT/ha; after one year of evaluation, the cadmium content is observed for each compost treatment 0.08 ppm, 0.17 ppm, 0.11 ppm; of chicken manure 0.09 ppm, 0.22 ppm, 0.28 ppm and in the control 0.19 ppm. **Conclusion:** The application of O.M. in cocoa plantations, cadmium of the grains decreases, reaching very small values of up to 0.08 ppm. USA comments that Cd cannot be volatilized under about 800°C. Soil Cd can be more strongly adsorbed can be leached, but not volatilized. In addition, the organic matter allows you to increase the capacity of cation exchange.

Use of zinc sulphate in fertilizer formulas

Zinc (Zn) has an antagonistic effect with Cd; Venezuelan studies determined that the Zn/Cd ratio higher than 1,000 meant a decrease in Cd adsorption in cocoa almonds, being determined up to 0.05 ppm.

CAICH conducted studies using three (03) doses of zinc sulfate to decrease Cd content in cocoa beans, using the following treatments: 0.00 kg. of zinc sulphate / plant, 0.09 zinc sulphate / plant, 0.18 zinc sulphate / plant and 0.27 zinc sulphate / plant. After one year of evaluation, the following results were obtained: 1.92 ppm, 1.83 ppm, 1.86 and 1.49 ppm respectively. **Conclusion**: Zinc sulphate has a positive effect on the decrease of cadmium content of cocoa beans. The application of zinc sulphate was carried out with the balanced fertilization that is carried out annually to the cocoa plantation, according to the requirements of the crop and the soil (characterization analysis).

Post-harvest treatment of cocoa beans

Cocoa CCN-51 is a clone with a high content of mucilage, superior to the Creole cocoas. Studies carried out in the CAICH showed quantities of Cd in the mucilage higher than the shell and the cotyledon. It is logical to suppose that during the process of fermentation of the grain there could be entry of Cd from the mucilage to the cotyledons. To clarify this hypothesis, the mucilage of the cocoa beans was drained for 24 hours in meshes, before entering the fermenting boxes; obtaining a reduction of 29.12% of the content of Cd in the cotyledons with respect to the control or control (cocoa beans without draining the mucilage). The results obtained on the content of Cd in cocoa almonds were: T1 (Yeast LB', without draining = 0.48 ppm), Control (Without yeast, without draining = 0.46 ppm), T2 (Drained 24 hours = 0.33 ppm), T3 (Yeast LB ', no draining, almond washing = 0.63 ppm). **Conclusion**: The draining of the mucilage had a positive effect on the decrease of cadmium in cocoa beans. **Note:** The amount of mucilage evacuated from cocoa beans did not affect the physical or organoleptic quality of the cocoa at the time of evaluation.

52. Peru

Hurtado, J. 2018. Peruvian University Cayetano Heredia. Studies in cultivation of cocoa

The Center for Cacao Innovation (CIC) with the Peruvian University Cayetano Heredia (UPCH) and the Agrarian University of La Molina (UNALM) are developing microbial inoculum for cadmium chelation. The project started in 2015 and will end in July 2019.

Microorganisms from 3 cocoa zones with high cadmium content have been isolated and microorganisms from coffee areas have been selected. Four microorganisms identified biochemically by 16S RNAr were selected by bioassays in indicator plants and cocoa seedlings. These microorganisms are being evaluated at field level in Fundo Verde (Pucallpa) in an area of 3 and half hectares. The results will be available in July 2019.

Likewise, metagenomic studies of cocoa crop populations are being carried out by means of last generation sequencing techniques (NGS), in order to characterize the biological diversity in these crops and confirm that the addition of microbial inoculants would not alter the genera predominantly present in the rhizosphere of these crops. In the future we could postulate the role that the different microbial and modular groups would have in their activity in a more adequate way.

POST-HARVEST MEASURES TO PREVENT AND REDUCE CADMIUM CONTAMINATION

53. Mucilage drainage for 12 hours during fermentation significantly reduced cadmium content in CCN-51 cocoa beans. Davila, C. 2018.

54. Drying: Ensure beans cannot be contaminated by smoke, fumes from dryers or vehicles.

Cocoa beans should be dried off the ground so that they are not in direct contact with soil, tarmac or concrete and are inaccessible to animals. (CAOBISCO/ECA/FCC.2015).

55. Storage: Ensure stores are not contaminated by fuel spills, exhaust fumes or smoke. (CAOBISCO/ECA/FCC.2015).

56. The risk of contamination of cadmium after harvesting during grain storage periods can be managed in a more predictable manner through Good Agricultural Practices (GAP) and Good Manufacturing Practices (GMP) that ensure that moisture levels in the grain stored below the levels that are propitious to mitigate Cadmium according to environmental conditions present in the region The moisture content of the stored cocoa beans should be checked periodically and kept below 8 % on drying. (CAC/RCP 72-2013)

57. Although it is practiced with some large purchases of cocoa beans, analyzing the shipment of batches of cocoa beans before the process should become a standard practice for mixing grains with higher levels of cadmium with grains of lower levels of cadmium. This practice is being done in some South American countries. ADEX, adds that this practice is common during the processing of grain to cocoa derivatives, not only to decrease levels of cadmium, but, mainly, to achieve the organoleptic characteristics requested by the target market. The representative of the Ministry of Agriculture and Irrigation of Peru specifies that, as far as possible, the mixing of grains should be avoided since it is a short-term commercial solution, but the problem is not solved, identity and origin that characterizes is lost to countries that produce fine aroma cocoa. It also indicates that it is necessary to implement a traceability of the cadmium content.

ADDITIONAL TOPICS RAISED BY EWG MEMBERS

58. The German Confederation of Confectioners for the Latin American producers (Gutiérrez E and León C. 2017.): Bear in mind that the cultivation of cocoa is a long-term investment (to obtain a mature plant it takes 5 years, then it produces by 60 years). Therefore, farmers should be warned to cultivate in free (or low-content) soils of cadmium. This is important, especially for cocoa type CCN51 (new clone developed in Ecuador derived from the "national" type of cocoa) which has the disadvantage of accumulating a higher proportion of cadmium in the plant.

59. Nicaragua recommends standardizing the methodology of soil and water sampling, as well as laboratory methods.

60. The U.S. Food and Drug Administration, recommends that the role of mycorrhizae in reducing cadmium availability and uptake needs further research, and there is a need to investigate on use of phytoremediation for crops such as cacao because to date there is little research, an also comments that coffee accumulates cadmium as much as cocoa does because there is little research in this area.

61. Peru through Universidad Nacional Cayetano Heredia (UPCH) recommends that it should be studied Cd accumulation in cover systems in order to give advice on cadmium excluder plants that do not increase Cd in soils.

62. Ecuador considers indicating that regional efforts that are being executed or planned to be executed, such as the project with funds from FONTAGRO.

ACKNOWLEDGMENT

63. The Chair of the EWG (SENASA Peru) wishes to highlight the valuable comments of AGROCALIDAD - Agency for Plant and Animal Health and Sanitary Regulation and Control (Ecuador), the National Health Surveillance Agency - ANVISA of Brazil, the General Agricultural Directorate - Ministry of Agriculture and Irrigation of Peru, Centro de Innovación de Cacao (SIC), Universidad Peruana Cayetano Heredia (UPCH), Universidad Nacional Agraria de la Molina (UNALM), the Ministry of Development, Industry and Commerce of Nicaragua, the U.S. Food and Drug Administration. Center for Food Safety and Applied Nutrition - United States of America and the Federal Department of Home Affairs (FDHA). Federal Food Safety and Veterinary Office FSVO. Division Food and Nutrition – Switzerland, Mexican Codex Alimentary Subcommittee on Food Contaminants, Malaysian Codex Committee on contaminants in foods.

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APPENDIX IV

LIST OF PARTICIPANTS ON THE EWG

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