Foreword

This *Code of Practice for the Prevention and Reduction of Ochratoxin A (OTA) Contamination in Philippine Cacao Beans* was developed in response to the development of a Codex *Code of Practice for the Prevention and Reduction of Ochratoxin A Contamination in Cocoa* by the Codex Committee on Contaminants in Food. The Codex Code of Practice was approved in 2013. This Code of Practice is therefore an adoption of this Codex Code of Practice with some modifications to suit the local production practices in the Philippines. This Code of Practice specific for *OTA* prevention and reduction is a supplement to the existing *Code of Practice for Philippine Cacao Beans* (PNS/BAFPS 104:2011) and should be read in conjunction with it.

A Technical Working Group (TWG) was created through Special Order No. 104 Series of 2013 to develop the draft Code of Practice. The TWG represented the relevant agencies of the Department of Agriculture (DA), Department of Health (DOH), Department of Science and Technology (DOST), the National Codex Organization (NCO) and a non-profit organization. Public consultations were conducted in Butuan, Cagayan de Oro, Cebu, Davao and the National Capital Region (NCR), representing the major hubs of cacao production and trade. Comments and recommendations were solicited from the relevant government agencies, academe, private sector and non-government organizations. Therefore, this Code of Practice is the final output of the public-private sector collaboration between and among the TWG and the relevant stakeholders who participated in the public consultations.

I. Introduction

1. This document is intended to provide guidance for all interested parties producing and handling cacao beans for human consumption to prevent and reduce *OTA* contamination in cacao beans. All cacao beans should be prepared and handled in accordance with the *Codex General Principles of Food Hygiene (CAC/RCP 1-1969, Rev. 4, 2003)*, which are relevant for all foods being prepared for human consumption. This Code of Practice indicates the measures that should be implemented by all persons that have the responsibility for assuring that food is safe and suitable for human consumption.

2. *Ochratoxin A* (*OTA*) is a toxic fungal metabolite classified by the International Agency for Research on Cancer (IARC) as a possible human carcinogen (group 2B). The Joint Food and Agriculture Organization (FAO)/World Health Organization (WHO) Expert Committee on Food Additives (JECFA) established a Provisional Tolerable Weekly Intake (PTWI) of 100ng/kg bodyweight for *OTA*. *OTA* is produced by a few species in the genera *Aspergillus* and *Penicillium*. In cacao beans, studies have shown that only *Aspergillus* species, specifically *A. carbonarius* and *A. niger* aggregate, with lower numbers of *A. westerdijkiae, A. ochraceus* and *A. melleus* are involved in *OTA* production. *OTA* is produced when favorable conditions of water activity, nutrition and temperature required for growth of fungi and *OTA* biosynthesis are present.

3. The fruit of cacao derived from the cacao tree, *Theobroma cacao L.*, is composed of pericarp, tissue that arises from the ripened ovary wall of a fruit, and the ovary. When the fruit (also called as pod) is ripe, the external tissue, consisting of thick and hard organic material (also called as pod husk), could be used as compost, animal feed and a source of potash. The ovary contains numerous seeds embedded in an aqueous, mucilaginous and acidic pulp. This white and off-white edible pulp is composed of about 12% sugars and due to its high citric acid content has a low pH (3.3 – 4.0). The pulp contains up to 10% pectin. The pulp may be used for making jams and jellies as well as alcoholic beverages and vinegar.

4. The main commercial use resides in the seeds, also known as the cacao beans. The cacao bean is composed of an episperm or integument, embryo and cotyledon. The integument, the protective layer of the seed, is also called shell when it is dried. During fermentation the embryo dies. Upon drying, the fat content of the dried cacao bean ranges between 34% and 56%, depending upon the cacao variety.

5. After proper fermentation and drying processes the cacao beans are sorted and graded based on the proportion of defective cacao beans as specified in the Philippine National Standards for Cacao or Cocoa Beans (PNS/BAFPS 58:2008) followed by proper bagging. The cacao beans are further processed to produce various commercial cacao products such as chocolate and chocolate products.

6. Since the cacao beans are extracted from a fruit, contamination by microorganisms may occur and the development of *OTA*-producing fungi could begin when conditions become appropriate for growth. Generally the fermentation and drying processes could create this favorable condition when these processes are not properly done.

7. It is important to emphasize that in the next manufacturing steps (which involve roasting, removal of shells, grinding, liquoring and refining), only the stage of shell removal can

significantly reduce *OTA* levels. The cacao industry should establish food safety specific programs to reduce the *OTA* levels in the processed cacao products meant for human consumption.

8. In the Philippines, the microbiota of cacao had been investigated by the Philippine Center for Postharvest Development and Mechanization (PHilMech). Different groups of microorganisms are associated with cacao beans at different levels of postharvest operation. Even before fresh beans reach the fermentation box, *Enterococcus casseliflavus* was found in the beans. More fermenting organisms like *Bacillus pumilus* and *Candida incommunis* complete the fermentation process. *Aspergillus niger, A. carbonarius*, *A. fumigatus*, *A. tamarii*, *A. flavus* and *Penicillium sp.*, along with *Mucor sp*., were found present in cacao beans in dried form. Most of these fungi found in the dried cacao beans are capable of producing mycotoxins like *OTA*.

II. Definitions

For the purpose of this Code, the following terms are operationally defined:

Parts of the cacao fruit (please see Figure 1)

Broken bean – a cacao bean of which a fragment is missing, the missing part being equivalent to less than half of the bean.

Cacao bean – the seed of the cacao fruit composed of episperm (integument), embryo and cotyledon.

Cacao pod – the cacao fruit pericarp that arises from the ripened ovary wall of a fruit.

Contaminated bean – a cacao bean which is contaminated by odors or flavors, or by dust from other products such as other foods, or by products such as oil, cement and tar.

Damaged beans – physically or mechanically damaged beans.

Defective beans - cacao beans which are internally moldy, slaty, insect-damaged, or insect-infested or germinated.

Double bean - two beans fused together which can be separated by hand.

Drying process – drying of cacao 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.

Dry cacao bean – a commercial term designating cacao beans which have been evenly dried throughout and which the moisture content of 7.5% corresponds to the requirements of this standard.

Episperm or integument – the protective layer of the seed also called shell when it is dried.

Fermentation – a process that produces the chocolate flavor in cacao beans. It occurs in two stages: (a) fermentation of sugars in pulp surrounding the cacao beans producing alcohol and

acetic; and (b) the acetic acid produced penetrates through the bean and causes biochemical reactions in the bean that is responsible for the formation of chocolate flavor precursors and classic chocolate brown color.

Fermented bean – a cacao bean of which the color of the cotyledons should range from partly purple and partly brown to a fully brown color as shown by the cut test.

Flat bean – a cacao bean of which the two cotyledons are so thin that is not possible to obtain a cotyledon surface by cutting.

Germinated bean – a cacao bean with the shell pierced, slit or broken by the growth of seed germ.

Grading - classification of cacao beans according to the proportion of defective beans and other criteria determined by the method of test specified in ISO/R1114 and PNS/BAFPS 58:2008.

Grinding – process of crushing the fermented and roasted cacao nib into liquor form.

Harvesting and pod breaking - fruits are manually harvested and opened using a recommended pod breaker.

Insect damaged/infested bean – a cacao bean with the internal parts of which contains insects at any stage of development, or has been attacked by insects, which has caused damage visible to the naked eye.

Moldy bean – a cacao bean in which mold is visible on the internal parts to the naked eye.

Philippine cacao beans – cacao beans produced/grown in the Philippines that have been fermented and dried.

Piece of shell - part of the shell without adhering nib or part of the nib.

Pulp - aqueous, mucilaginous and acidic substance in which the seeds are embedded.

Roasting – heat treatment that produces fundamental chemical and physical changes in the structure and composition of cacao beans and brings about darkening of the beans and the development of the characteristic chocolate flavor of roasted cacao.

Shell – the external covering or the protective layer of the seed, also called episperm or integument.

Slaty bean – a cacao bean which shows a slaty characteristic over half or more of the surface exposed by a cut made lengthwise through the centre using the method described in ISO/R 1114 and PNS/BAFPS 58:2008.

Smoky bean – a cacao bean which has a smoky smell or taste or which shows signs of contamination by smoke.

Sorting - operation intended to remove foreign matter, fragments of dried cacao beans, pod and pulp; remove defective beans from fermented and dried cacao beans; and to separate big from small beans.

Waste - flat bean, fragments, pieces of shell, dried placenta and dried pulp.

III. Processing of Philippine Cacao Beans

9. Harvesting involves manually removing the pod from the tree using a pruning shear, selector knife, or cacao hook on a stick.

10. The pods are opened using a baton or pod splitter immediately after harvest or within 7 days after harvest, and seeds or wet beans are taken out of the pod.

11. The wet cacao beans are fermented in boxes or heaped together in baskets normally for five (5) days with turning after two (2) days to allow microorganisms to develop and initiate the fermentation process.

12. The fermented cacao beans are usually sun-dried within five (5) to seven (7) days in elevated solar dryers, or mechanically dried in artificial dryers, or a combination of both sun-drying and mechanical drying.

13. When the beans are appropriately dried to the ideal moisture level of 7.5%, these must be sorted to remove the flat, slaty, black, moldy, small, double beans, and insect damaged/infested beans. They are graded based on the proportion of defective beans as specified in the *Philippine National Standards for Cacao or Cocoa Beans (PNS/BAFPS 58:2008),* or as specified by the buyer.

14. Fermented and dried cacao beans are placed in appropriate bags and stored. Appropriate bagging and storage of the fermented and dried cacao beans is just as important as proper fermentation and drying. The cacao beans are ready to be sold and used for processing of Philippine *Tablea* and other chocolate products.

15. A major part of *OTA* originally present in cacao beans is found in the shell/husk fraction. Accordingly, removing cacao shells/husk/dried episperm or integument of the cacao seed, before and after the roasting process can reduce *OTA* levels significantly.

IV. Recommended Practices

4.1 Pre-Harvest

16. The pulp and the cacao beans are microbiologically sterile in relation to *OTA*- producing fungi while inside the healthy cacao pod. The contamination by spores of fungi that can produce *OTA* occurs during the opening process of the cacao pod and in the subsequent processes.

17. Consequently the cacao plantation should be properly maintained to ensure as low a level of mold growth as possible, in order to avoid contamination of *OTA*-producing fungal spores during opening of the cacao pod.

18. Recommended practices to reduce contamination from *OTA*-producing fungi in cacao beans are:
    a) Keep cacao plants healthy, through the adoption of Good Agricultural Practices (GAP) such as weeding, improving soil texture, prevention of soil erosion, pruning, fertilizer application such as the use of fully decomposed organic fertilizer, pest and disease

control, and irrigation. For establishment of new cacao farms, cacao trees should be planted in the most suitable soil, pattern and density to ensure easy management of the farms.

b) Do not use overhead irrigation during the flowering and fruit development period. This could augment normal spore dispersal rates and increase the chance of infection of beans by *OTA* producers.

c) Avoid disposal of uncomposted organic wastes from cacao or any other source, in or around the cacao plantation. Cacao seeds and seed-associated material, such as dust, earth, and other seed may promote proliferation of *OTA*-producing fungi.

4.2 Pod Harvesting

19. Cacao pods should be harvested as soon as they are ripe (approximately 75% ripeness) which is indicated by a change in color depending on the cacao variety.

20. Harvesting should be done every week during peak periods and every two weeks in non-peak periods. Harvested pods may be stored for seven (7) days in a shaded area.

21. A separate round of farm sanitation should be conducted every week to remove diseased cacao pods with a selector knife, pruning shear or cacao hook on a stick that is used only for that purpose. Separate and discard diseased and infested pods from healthy pods right in the field to avoid contamination during transport and storage.

22. Mummified pods should be discarded because they are more likely to be infected.

23. Harvesting unripe pods should be avoided. The unripe cacao pods have a solid pulp and without mucilage. Hence the unripe cacao pods are difficult to separate from the pod, do not ferment properly, and can contribute to slaty beans.

24. Harvesting over-ripe pods should likewise be avoided. Over-ripe pods are likely to have germinated seeds and contribute to the end-product defect classified as “germinated beans” (PNS/BAFPS 58:2008). Discard over-ripe pods if present.

25. The harvester should avoid unnecessary cutting/wounding of the cacao pods to prevent contamination and development of *OTA*-producing fungi in the cuts/wounds in the pod.

26. Harvesting must be carried out using specific techniques and tools. The tools and baskets used to transport the pods must be cleaned regularly.

4.3 Pod Breaking and Removal of Seeds

27. Once a sufficient quantity of pods suitable for fermentation has been harvested, the pods must be opened manually using wooden batons or pod splitters and the cacao beans extracted. Care should be taken not to damage the beans during pod breaking.

28. It is recommended to open the pods within seven (7) days after harvesting in order to avoid fungal proliferation, avoid over-ripening of the pods, and initiate the fermentation process.

29. Wounded or damaged pods during the process of harvesting should be opened and fermented as soon as possible.

30. Tools (*i.e.* pod splitter, wooden baton, etc.) used to open the cacao pods should be cleaned regularly as appropriate.

31. Removal of wet beans is done manually using a scooping tool/scooper. Personnel should maintain an appropriate degree of personal hygiene during the manual removal of seeds.

32. During the opening process, any defective parts of the cacao pod, moldy beans, diseased beans, and damaged beans should be removed and appropriately disposed of.

33. Good quality wet beans should be placed in a suitable container during transport. Transport of fresh/wet beans from pod opening sites to on-farm fermentation facility should be done under conditions that will prevent contamination (e.g., wet beans must be free of soil before being fermented and properly labelled based on the farm source for traceability purposes).

34. Suitable containers used during transport of wet beans should be cleaned regularly as appropriate.

4.4 Fermentation

35. Wet cacao beans should be placed in reasonably clean, dry, suitable, elevated boxes or baskets for the fermentation process.

36. Cacao beans should be fermented within five (5) days, depending on the method of fermentation. Avoid longer fermentation days as this could lead to fungal proliferation and seed germination.

37. Care should be taken to prevent wet cacao beans from getting in contact with water during fermentation by using covers over boxes and baskets.

38. Cacao beans should be turned 48 hours or two (2) days after loading in the fermentation boxes or baskets to ensure uniform heat in the heaps, to allow aeration, to break up any lumps and to prevent fungi proliferation.

39. Tools (paddle and shovel used for manual turning) and materials used during fermentation should be cleaned regularly. Organic materials used for fermentation should be discarded, when appropriate.

40. Fermentation is recommended to avoid ochratoxigenic fungal growth and *OTA* production because acetic, lactic and citric acid produced by bacteria during fermentation can compete with and inhibit these undesirable fungal species. Research has shown that fermentation carried out during drying on a drying mat; and partially depulped cacao also being fermented directly on the drying mat, can increase *OTA* production in cacao beans.

4.5 Drying

41. The fermented cacao beans must be spread immediately on appropriate elevated solar dryers (*i.e*. not directly on bare ground or concrete floor) preferably under direct sunlight to stop the fermentation process. If the drying is not started immediately, the cacao beans will keep on fermenting (over-fermentation will result in a loss of cacao flavour) and allow fungal growth.

42. The drying process could be done by direct sunlight or mechanical drying, or a combination of both (*i.e.* sun-drying for 1-2 days at full-day sunshine and finishing up with mechanical drying). A moisture content of a maximum of 7.5% in cacao beans is considered optimal in order to avoid growth of microorganisms and for good storage.

43. The drying area should be located away from contaminant sources and should receive maximum sun exposure and air circulation during most times of the day, to speed up the drying process of the cacao beans.

44. The layer of drying cacao beans should preferably not to exceed six (6) cm thick (which corresponds to 40 kg of wet cacao beans per square meter of drying area) to avoid slow or inadequate drying that may lead to fungal growth.

45. Beans must be turned several times each day to ensure uniformly dried beans. Rake over the cacao bean layer frequently, (*i.e.* 5 to 10 times during the daytime) to allow faster drying and reduce the risk of fungal growth.

46. Do not mix cacao beans at different drying stages. Use specific identification methods in order to distinguish and identify each drying stage.

47. Protect cacao beans during drying from rain and dew. The cacao beans should be heaped and covered at night or during rainy weather to avoid re-wetting.

48. Re-wetting of cacao beans should be avoided because cacao beans with a level of moisture above 7.5% can allow rapid growth of the mycelium and the possibility of *OTA* production. Moldy cacao beans should be discarded.

49. Protect the cacao beans from pests and domestic animals during drying, which can be a source of microbiological contamination.

50. Drying equipment and tools should be cleaned regularly.

4.6 Sorting and Grading

51. Before storage of the dried cacao beans, they must be sorted to remove flat, slaty, black, moldy, small, double, and insect damage/infested beans. They are also graded based on the proportion of defective beans as specified in the *Philippine National Standards for Cacao or Cocoa Beans (PNS/BAFPS 58:2008)*.

52. Facilities and equipment that are related with sorting and grading process should be regularly inspected, maintained and cleaned, in order to avoid physical damage to cacao

beans that make them more susceptible to contamination and deterioration, and to prevent the introduction of new contamination and undesirable materials.

53. An appropriate degree of personal hygiene should be maintained by all personnel.

4.7 Packing, Storage, Transport and Trading

54. Sorted and graded beans should be placed in appropriate bags and stored under the appropriate storage conditions prescribed for the sorting and grading area/location (Section 4.6). Stored beans must be properly identified by lots/batch.

55. Cacao beans should be packaged in clean bags which are sufficiently strong and properly sewn or sealed to withstand transport impacts and storage and which are suitable for food contact use and discourage pest infestation.

56. Bagged cacao beans must be placed in warehouses or storage sheds that are weather-proof, well-aerated, cleaned, free from dampness and pests, and away from smoke and other odoriferous materials that could contaminate the cacao beans.

a) The design and structure of the warehouses or storage sheds should be adequate to maintain dryness and uniformity of the stored dried cacao beans.
b) The cacao bags should be arranged on pallets and away from walls, to allow good air circulation.
c) The stored beans should not be exposed to direct sunlight nor stored near heating sources, to avoid the possibility of temperature differentials and water migration.
d) Cleaning and maintenance programs should be implemented and storage facilities should be periodically inspected, cleaned and repaired.

57. During the entire process, the cacao beans must also be protected from re-wetting, degradation and cross–contamination. In long-term storage conditions, humidity should be kept under strict control. Appropriate storage facilities should follow the use of good storage practice and conduct regular monitoring in order to prevent or reduce mold growth.

58. The moisture content of the stored cacao beans should be periodically checked and kept at 7.5%.

59. Any infestation must be dealt with by proper and approved methods of fumigation (as indicated in *PNS/BAFPS 58:2008*). Appropriate documentation accompanying the cargo should state in clear and correct terms the fumigants and the quantities that were used.

60. From the production areas, cacao beans may be conveyed by various means to the trading points. The main aspect of concern here is to avoid re-wetting of cacao beans, due to possible climatic changes among different regions, and taking the necessary control measures.

61. Transport of cacao beans also requires the adoption of practices to avoid re-wetting, to maintain temperature as uniform as possible and to prevent contamination by other materials. The main requirements here are:

a) Cover cacao bean loading and unloading areas to protect against rain.
b) Before receiving a new cargo, the vehicles must be cleaned from residues of previous cargo.
c) The vehicles must have floor, sidewalls and ceilings (in closed vehicles) checked for the presence of points where exhaust fumes or water from rain can be channeled into the cacao cargo. Tarpaulins and plastic canvas used to cover the cargo should also be regularly checked to ensure that they are clean and without holes. The vehicles should also receive regular maintenance and should be kept in good condition.
d) Operators should select reliable transport service-providers that adopt the recommended good transportation practices.

4.8 Cargo Ship Loading and Transport

62. Cacao beans are transported from the Philippines to other countries in jute sacks, usually in 20 to 40-footer containers. Temperature fluctuations, during transportation time, can cause condensation of the remaining water (present even in well-dried beans) and local re-wetting. The redistribution of water can lead to fungal growth, with the possibility of *OTA* production. The recommended practices during transportation in the port are:

a) Cover cacao loading and unloading areas to protect against rain.
b) Check cacao lots to ensure that they are uniformly dried and not higher than 7.5% moisture content, free of foreign matter and conforming to the established defect levels.
c) Check containers before loading to ensure they are clean, dry and without structural damage that could allow water to enter into the container.
d) Bags should be well stacked and crossover for mutual support in order to avoid formation of empty vertical columns (chimneys). The top layer and sides of bags should be covered with materials that can absorb condensed water, such as silica gel or cardboard for protection against growth of fungi that could result in *OTA* production.
e) Choose an appropriate place, not directly exposed to outside elements, aboard the ship to store the dried cacao beans to reduce the possibility of undesirable situations mentioned that can lead to *OTA* contamination.
f) Keep ventilation holes in the containers free from clogging.
g) Avoid unprotected stowage on deck (top layer) and stow away from boilers and heated tanks or bulkheads.
h) The moisture content should not exceed 7.5% anywhere, from the point where the dried cacao beans leave the loading area to the point at which it is unloaded, stored and/or subjected to other processing procedures such as roasting.

63. The complete cacao value chain flowchart is shown in Figure 2.

References:

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International Organization for Standardization (ISO). Cocoa Beans- Cut Test (ISO1114:1977).

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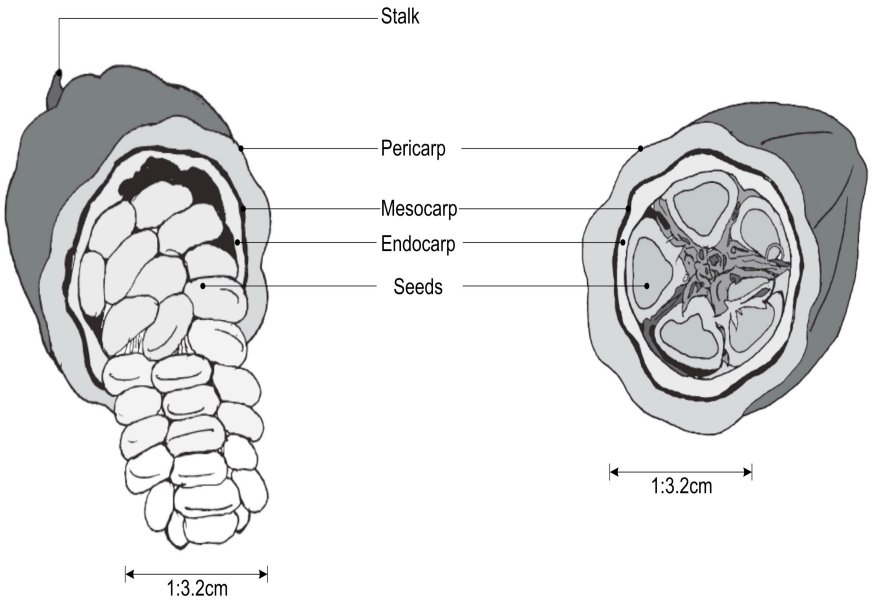

Figure 1a. Longitudinal and transverse sections of a cacao pod (Codex Committee on Contaminants in Food, 2013) [Scale: 1: 3.2cm]

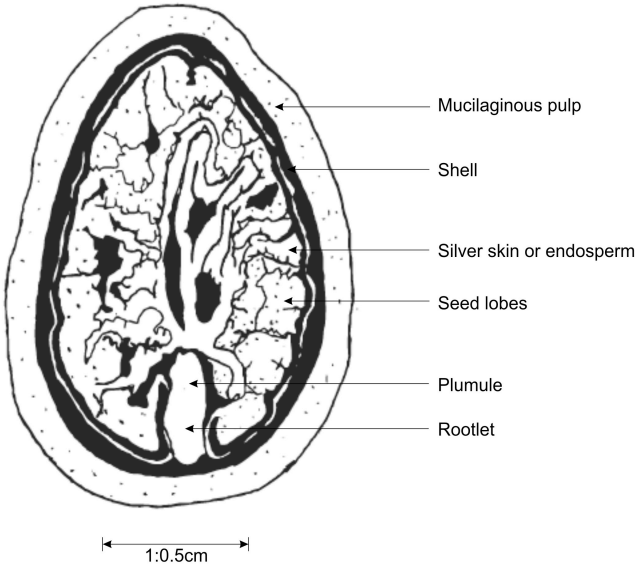

Figure 1b. Longitudinal section of a cocoa seed (Codex Committee on Contaminants in Food, 2013) [Scale: 1: 0.5cm]

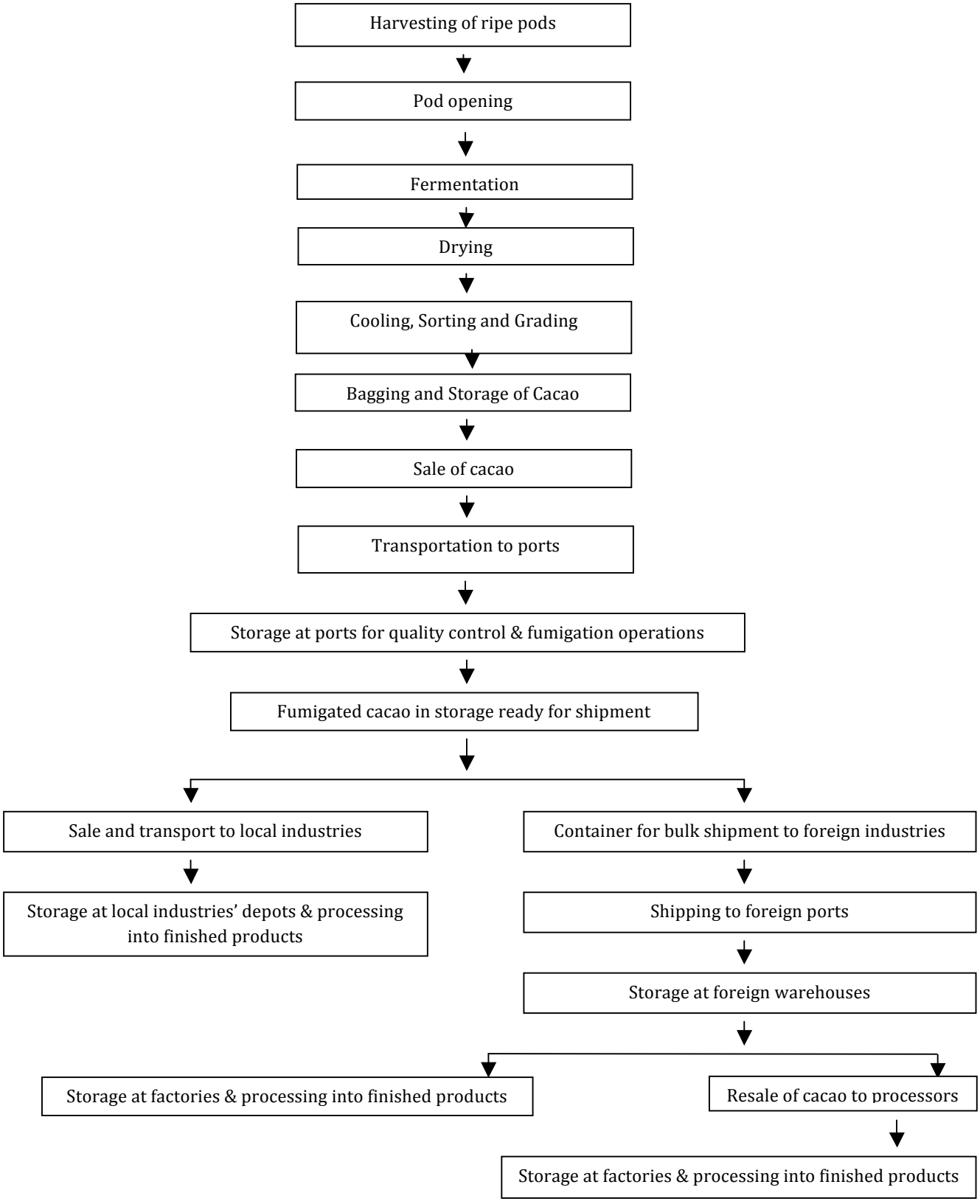

Figure 2. Cacao Beans Value Chain (Codex Committee on Contaminants in Food, 2013)

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Bureau of Agriculture and Fisheries Product Standards (BAFPS)

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