

Foreword

This *ASEAN Code of Practice for the Prevention and Reduction of Ochratoxin A (OTA) Contamination in Cocoa 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 (CAC/RCP 72-2013) by the Codex Committee on Contaminants in Food. The Codex Code of Practice was adopted by the Thirty-Sixth Session of the Codex Alimentarius Commission (CAC) in 2013. This Code of Practice is therefore an adoption of the Codex Code of Practice with some modifications to suit the common local production practices within ASEAN. This Code of Practice specific for *OTA* prevention and reduction is a supplement to the *ASEAN Good Agriculture Practices (GAP) for Cocoa Beans* and should be read in conjunction with it.

The *ASEAN Code of Practice for the Prevention and Reduction of Ochratoxin A (OTA) Contamination in Cocoa Beans* was developed by the ASEAN Cocoa Club Technical Working Group on Food Safety (ACC TWGFS) in 2013 and adopted by The 17th Meeting of the National Focal Point for the ASEAN Cocoa Club (ACC) on ASEAN Cooperation and Joint Approaches in Agriculture and Forest Products Promotion Scheme in 2014.

I. Introduction

1. This document is intended to provide guidance for all interested parties producing and handling cocoa beans for human consumption to prevent and reduce *OTA* contamination in cocoa beans. All cocoa 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 cocoa 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 cocoa derived from the cocoa tree, *Theobroma cocoa L.*, is composed of pericarp, tissue that arises from the ripened ovary wall of a fruit, and the ovary. When the fruit (also known as pod) is ripe, the external tissue, consisting of thick and hard organic material (also known 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 cocoa beans. The cocoa 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 cocoa bean ranges between 34% and 56%, depending upon the cocoa variety.
5. After proper fermentation and drying processes the cocoa beans are sorted and graded based on the proportion of defective cocoa beans followed by proper bagging. The cocoa beans are further processed to produce various commercial cocoa and chocolate products.
6. Since the cocoa 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 removing of shells, roasting (or vice versa), grinding/liquoring and refining), only the stage of shell removal can significantly reduce *OTA* levels. The cocoa industry should establish food safety specific programs to reduce the *OTA* levels in the processed cocoa products meant for human consumption.

II. Definitions

Parts of the cocoa fruit (Figure 1)

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

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

Cocoa pod – the cocoa fruit pericarp that arises from the ripened ovary wall of a fruit.

Contaminated bean – a cocoa 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 - cocoa beans which are internally moldy, slaty, insect-damaged, or insect-infested or germinated.

Double bean - two beans fused together which cannot be separated by hand.

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.

Dry cocoa bean – a commercial term designating cocoa beans which have been evenly dried throughout and which the moisture content of below 8% 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 cocoa beans. It occurs in two stages: (a) fermentation of sugars in pulp surrounding the cocoa beans producing alcohol and acetic acid; 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 cocoa 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 cocoa bean of which the two cotyledons are so thin that is not possible to obtain a cotyledon surface by cutting.

Foreign matter – any substance other than cocoa bean and residue.

Fused beans – three or more cocoa beans fused together.

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

Grading - classification of cocoa beans according to the proportion of defective beans and other criteria determined by the method of test specified in ISO 1114:1977 or in the national standards of the ASEAN Member States (AMS).

Grinding – process of crushing the fermented and roasted cocoa bean/nib into liquor form.

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

Insect damaged/infested bean – a cocoa 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 cocoa bean in which mold is visible on the internal parts to the naked eye.

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 cocoa beans and brings about darkening of the beans and the development of the characteristic chocolate flavor of roasted cocoa.

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

Slaty bean – a cocoa bean which shows a slaty colour over half or more of the surface exposed by a cut made lengthwise through the centre using the method described in ISO R 1114:1977 or in the national standards of the AMS.

Smoky bean – a cocoa 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 cocoa beans; remove defective beans from fermented and dried cocoa beans; and to separate big from small beans.

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

III. Processing of Cocoa Beans

8. Harvesting involves manually removing the pod from the tree by hand or using a sharp tool (e.g. pruning shear, selector knife, cutter or cocoa hook on a stick).
9. The pods are opened using a pod breaker (e.g. baton or pod splitter, machete) immediately after harvest or within seven (7) days after harvest, and seeds or wet beans are taken out from the pod.
10. For fermented cocoa beans, the wet cocoa beans are fermented in boxes or heaped together in baskets normally for four to seven (4-7) days with turning after two (2) days to allow microorganisms to develop and initiate the fermentation process.
11. The cocoa beans are usually dried within five to seven (5-7) days by sun or solar drying, or a combination of both sun/solar drying and mechanical drying.
12. When the beans are appropriately dried to the ideal moisture level of below 8%, they must be sorted to remove the flat, black, moldy, double, fused beans, and insect damaged/infested beans. They are graded based on the proportion of defective beans or as specified by the buyer.

13. Dried cocoa beans are placed in appropriate bags and stored. Appropriate bagging and storage of the fermented and dried cocoa beans is just as important as proper fermentation and drying. The cocoa beans are ready to be sold and used for processing of cocoa and chocolate products.
14. A major part of *OTA* originally present in cocoa beans is found in the shell fraction. Accordingly, removing cocoa shells/dried episperm or integument of the cocoa seed, before and after the roasting process can reduce *OTA* levels significantly.

IV. Recommended Practices

4.1 Pre-Harvest

15. The pulp and the cocoa beans are microbiologically sterile in relation to *OTA*-producing fungi while inside the healthy cocoa pod. The contamination by spores of fungi that can produce *OTA* occurs during the opening process of the cocoa pod and in the subsequent processes.
16. Consequently the cocoa 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 cocoa pod.
17. Recommended practices to reduce contamination from *OTA*-producing fungi in cocoa beans are:
 - a) Keep cocoa plants healthy, through the adoption of Good Agricultural Practices (GAP) such as weeding, improving soil texture, prevention of soil erosion, pruning, suitable shading, fertilizer application such as the use of fully decomposed organic fertilizer, pest and disease control, and irrigation. For establishment of new cocoa farms, cocoa 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 cocoa or any other source, in or around the cocoa plantation. Cocoa seeds and seed-associated material, such as dust, earth, and other seed may promote proliferation of *OTA*-producing fungi.

4.2 Pod Harvesting

18. Cocoa pods should be harvested as soon as they are ripe (approximately 75% ripeness) which is indicated by a change in color depending on the cocoa variety.
19. 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 and not directly on the ground.
20. A separate round of farm sanitation should be conducted every week to remove diseased cocoa pods by hand or using a sharp tool (e.g. pruning shear, selector knife,

cutter or cocoa 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.

21. Mummified pods should be discarded because they are more likely to be infected.
22. Harvesting unripe pods should be avoided. The unripe cocoa pods have a solid pulp and without mucilage. Hence the unripe cocoa beans are difficult to separate from the pod, do not ferment properly, and can contribute to slaty beans.
23. 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”. Discard over-ripe pods if present.
24. The harvester should avoid unnecessary cutting/wounding of the cocoa pods to prevent contamination and development of *OTA*-producing fungi in the cuts/wounds in the pod.
25. Harvesting must be carried out using specific techniques and tools. The tools and baskets used to transport the pods must be cleaned and tools must be sharpened regularly.

4.3 Pod Breaking and Removal of Seeds

26. Once a sufficient quantity of pods suitable for fermentation has been harvested, the pods must be opened manually using wooden batons or pod splitters, machete and the cocoa beans extracted. Care should be taken not to damage the beans and introduce contamination during pod breaking.
27. It is recommended to open the pods immediately or within seven (7) days after harvesting in order to avoid fungal proliferation, avoid over-ripening of the pods, and initiate the fermentation process.
28. Wounded or damaged pods during the process of harvesting should be opened and fermented as soon as possible.
29. Tools (*i.e.* pod splitter, wooden baton, machete etc.) used to open the cocoa pods should be cleaned regularly.
30. 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.
31. During the opening process, moldy beans, diseased beans, and damaged beans should be removed and appropriately disposed of.
32. Good quality fresh/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. fresh/wet beans must be free of soil before being fermented and properly labelled based on the farm source for traceability purposes).

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

4.4 Fermentation

34. Wet cocoa beans should be placed in reasonably clean, dry, suitable, elevated boxes or baskets for the fermentation process.
35. Cocoa beans should be fermented between four to seven (4-7) days, depending on the method of fermentation. Avoid longer fermentation days as this could lead to fungal proliferation.
36. Fermentation boxes or baskets should be covered to regulate the fermentation temperature.
37. Cocoa 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.
38. Tools (paddle and shovel used for manual turning) and materials used during fermentation should be cleaned regularly. Organic materials (e.g. banana leaves) used for fermentation should be discarded, when appropriate.
39. Fermentation is recommended to avoid ochratoxigenic fungal growth and *OTA* production because acetic, lactic and citric acids 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 cocoa also being fermented directly on the drying mat, can increase *OTA* production in cocoa beans.

4.5 Drying

40. The fermented cocoa beans must be spread immediately on appropriate elevated solar dryers (*i.e.* not directly on bare ground, preferably under direct sunlight to stop the fermentation process, surface of solar dryers should allow good ventilation). If the drying is not started immediately, the cocoa beans will keep on fermenting (over-fermentation will result in a loss of cocoa flavor) and allow fungal growth.
41. The drying process could be done by direct sunlight or mechanical drying, or a combination of both. A moisture content of below 8% in cocoa beans is considered optimal in order to avoid growth of microorganisms and for good storage.
42. 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 cocoa beans. Shady areas should be avoided.
43. In rainy or wet regions, cocoa beans must be covered and re-spread once the drying surface has dried. Ensure that the drying surface is clean and located away from contaminants sources.

44. The layer of drying cocoa beans should preferably not to exceed six (6) cm thick (which corresponds to 40 kg of wet cocoa 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 cocoa bean layer frequently, to allow faster drying and reduce the risk of fungal growth.
46. Do not mix cocoa beans at different drying stages. Use specific identification methods in order to distinguish and identify each drying stage.
47. Protect cocoa beans during drying from rain and dew. The cocoa beans should be heaped and covered at night or during rainy weather to avoid re-wetting.
48. Re-wetting of cocoa beans should be avoided because cocoa beans with a level of moisture above 8% can allow rapid growth of the mycelium and the possibility of *OTA* production. Moldy cocoa beans should be discarded.
49. Protect the cocoa 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 cocoa beans, they must be sorted to remove foreign matter, fragments of dried cocoa beans; remove defective beans from fermented and dried cocoa beans; and to separate big from small beans. They are also graded according to the proportion of defective beans and other criteria determined by the method of test specified in ISO 1114:1977 or in the national standards of the ASEAN Member States (AMS).
52. Facilities and equipment that are related with sorting and grading processes should be regularly inspected, maintained and cleaned, in order to avoid physical damage to cocoa 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 (*paragraph 52*). Stored beans must be properly identified by lots/batch.
55. Cocoa 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 cocoa 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 cocoa beans.
- a) The design and structure of the warehouses or storage sheds should be adequate to maintain dryness and uniformity of the stored dried cocoa beans.
 - b) The cocoa bags should be arranged on dry and clean 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 cocoa beans must also be protected from re-wetting, degradation and cross-contamination. For long-term storage, humidity should be kept low. 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 cocoa beans should be periodically checked and kept below 8%.
59. Any infestation must be dealt with by proper and approved methods of fumigation. 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, cocoa beans may be conveyed by various means to the trading points. The main aspect of concern here is to avoid re-wetting of cocoa beans, due to possible climatic changes among different regions, and taking the necessary control measures.
61. Transport of cocoa 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 cocoa 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 cocoa 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. Cocoa beans are transported 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 cocoa 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 cocoa loading and unloading areas to protect against rain.
 - b) Check cocoa lots to ensure that they are uniformly dried and below 8% 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 cocoa beans to reduce the possibility of undesirable situations mentioned that can lead to *OTA* contamination.
 - f) Avoid unprotected stowage on deck (top layer) and stow away from boilers and heated tanks or bulkheads.
 - g) The moisture content should be below 8% anywhere, from the point where the dried cocoa 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 cocoa consignment for import/export shall be accompanied with a Phytosanitary Certificate (PC) certifying treatment details from the country origin and free from pests, diseases and regulated articles. The statement “types of treatment and free from pest, diseases and contaminants” must be declared inside the Import Permit under additional declaration.
64. The complete cocoa value chain flowchart is shown in **Figure 2**.

References:

Codex Alimentarius Commission (CAC). Code of Practice for the Prevention and Reduction of *Ochratoxin A* Contamination in Cocoa (CAC/RCP 72-2013).

Codex Alimentarius Commission (CAC). Recommended International Code of Practice – General Principles of Food Hygiene (CAC/RCP 1-1969, Rev. 4, 2003).

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

International Organization for Standardization (ISO). Cocoa Beans - Specification (ISO/DIS 2451:1973).

Malaysian Standard: Cocoa Beans – Specification for Grading (4th revision) MS 293:2005.

Philippine National Standard: Code of Code of Practice for the Prevention and Reduction of *Ochratoxin A* Contamination in Philippine Cocoa Beans (PNS/BAFPS 130:2013).

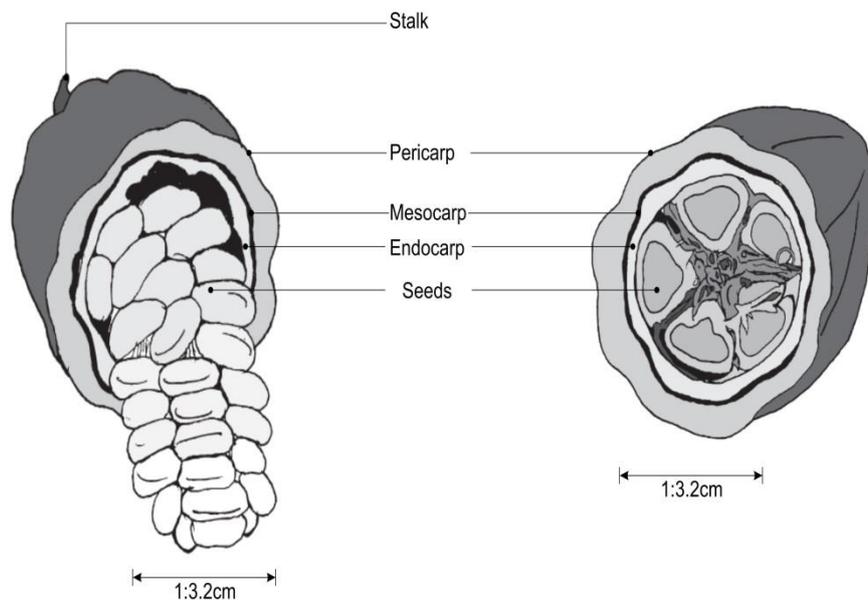


Figure 1a. Longitudinal and transverse sections of a cocoa pod [Scale: 1: 3.2cm](CAC/RCP 72-2013)

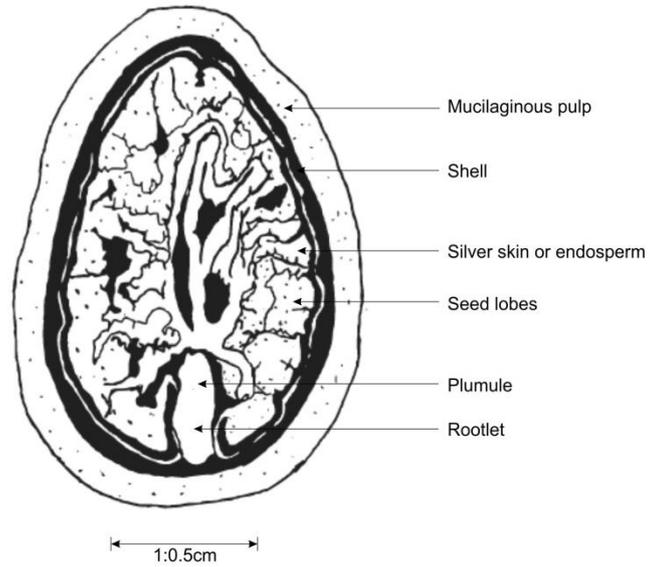


Figure 1b. Longitudinal section of a cocoa seed [Scale: 1: 0.5cm](CAC/RCP 72-2013)

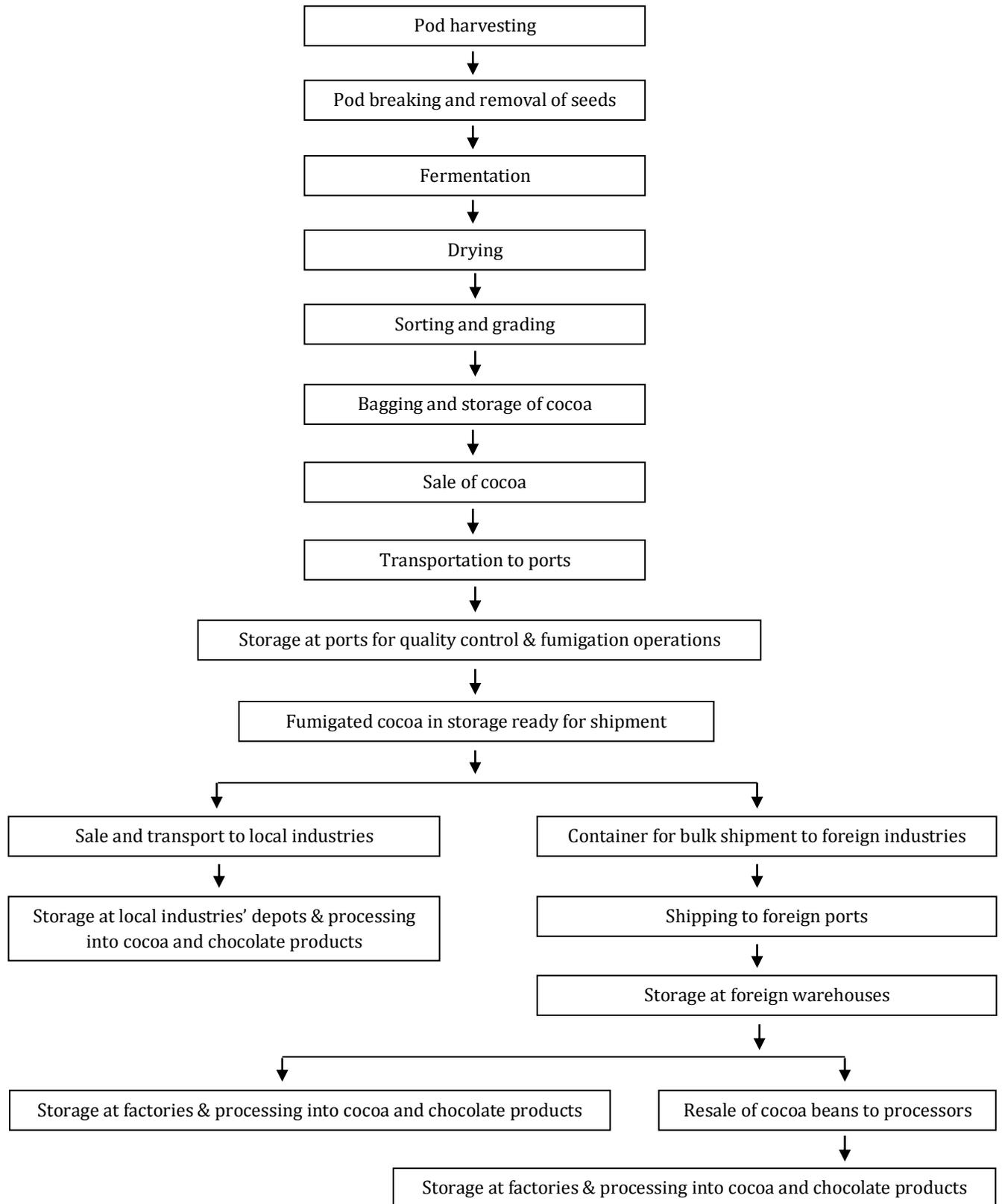


Figure 2. Cocoa Beans Value Chain (adopted from CAC/RCP 72-2013)