AFLATOXIN CONTAMINATION IN TREE NUTS

CXC 59-2005

INTRODUCTION

1. The elaboration and acceptance of a Code of Practice for tree nuts by Codex will provide uniform guidance for all countries to consider in attempting to control and manage contamination by various mycotoxins, specifically aflatoxins. In order for this Code of Practice to be effective, it will be necessary for the producers and processors in each country to consider the general principles given in the Code, taking into account the agronomic and extractivistic[1] practices associated with the tree nuts produced in their regions, before attempting to implement provisions enumerated in the Code. It is important for producers or extractivists to realize that Good Agricultural Practices (GAP) represent the primary line of defence against contamination of nuts with aflatoxins, followed by the implementation of Good Manufacturing Practices (GMP) Good Extractivistic Practices and Good Storage Practices (GSP) during the handling, processing, storage and distribution of nuts for human consumption. Only by effective control at all stages from the farm through to processing can excellent quality of the final product be assured. However, the complete elimination of mycotoxin contaminated commodities, including tree nuts, is not achievable at this time.

2. This Code of Practice applies to all varieties of tree nuts of commercial and international concern, including almonds (*Prunus amygdalus*), Brazil nuts (*Bertholletia excelsa*), cashews (*Anacardium occidentale*), hazel nuts (*Corylus* spp.), macadamia nuts (*Macadamia* spp.), pecans (*Carya* spp.), pine nuts (*Pinus* spp.), chestnuts (*Castanea* spp.), pistachio nuts (*Pistacia* spp.) and walnuts (*Juglans* spp.). It contains general principles for the reduction of aflatoxins in tree nuts that should be sanctioned by national authorities. National authorities should educate producers, extractivists, transporters, storage keepers and other operators of the production chain regarding the practical measures and environmental factors that promote infection and growth of fungi in tree nuts resulting in the production of aflatoxin in orchards or in the forest (areas of extractivism). Emphasis should be placed on the fact that the planting, pre-harvest and post-harvest strategies for a particular nut crop depends on the climatic

[1] Brazil Nuts Extractivism: this is the process of collection and primarily handling of Brazil nuts in the Amazon rainforest where Brazil nut trees grow in their natural environment.

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conditions of a particular year, and traditional production, harvesting and processing practices followed in a particular country or region. For Brazil nuts, the specific conditions related to extractivism have to be taken into account. National authorities should also support research on methods and techniques to prevent fungal contamination in the orchard or in the forest and during the harvesting, processing and storage of tree nuts. An important part of this is the understanding of the ecology of *Aspergillus flavus/parasiticus* in connection with tree nuts.

3. Fungi in the *Aspergillus* species are rapidly growing hyaline molds that are common opportunists found in the soil and on decaying matter. Their colonies are usually yellow, yellow-green, yellow-brown, or green; granular, velvety, or cottony; and have a white peripheral apron and a distinct margin.

4. The aflatoxin-producing *Aspergillus* species, and consequently dietary aflatoxin contamination, are ubiquitous in areas of the world with hot humid climates. *Aspergillus flavus/A. parasiticus* cannot grow or produce aflatoxins at water activities less than 0.7; relative humidity below 70% and temperatures below 10 ºC. Under stress conditions such as drought or insect infestation, aflatoxin contamination is likely to be high. Improper storage conditions can also lead to aflatoxin contamination after crops have been harvested. Usually, hot humid conditions lead to mould growth on the stored food and to high levels of aflatoxins.

5. Some procedures used to reduce and prevent aflatoxin production include: (1) selection of resistant varieties, if practicable, (2) minimize the presence of insects and other pests in the orchard during the growing phase, (3) minimize physical damage to nuts during harvesting and transportation, and (4) ensure that nuts are properly cleaned, dried and labelled when placed in a storage facility equipped with temperature and moisture controls.

1. SCOPE

6. This document is intended to provide guidance for all persons involved in producing tree nuts for entry into international trade for human consumption. All tree nuts should be prepared and handled in accordance with general hygienic principles and practices that are pointed out in appropriate sections of the Recommended International Code of Hygienic Practice for Tree Nuts[2], and the Recommended International Code of Practice- General Principles of Food Hygiene[3], which are relevant for all foods being prepared for human consumption. These codes of practice indicate the measures that should be implemented

[2] Recommended International Code of Hygienic Practice for Tree Nuts, CXC 6-1972, Codex Alimentarius Volume 5A.

[3] Recommended International Code of Practice- General Principles of Food Hygiene, CXC 1-1969, Rev. 4 (2003), Codex Alimentarius Volume 1A.

by all persons that have the responsibility for assuring that food is safe and suitable for consumption.

2. RECOMMENDED PRACTICES BASED ON GOOD AGRICULTURAL PRACTICES (GAP) GOOD MANUFACTURING PRACTICES (GMP) AND GOOD STORAGE PRACTICES (GSP)

2.1 Criteria for orchard sites or picking sites

7. Growers should obtain background information concerning the potential orchard site to determine if: (1) the soil composition is ideal to support the growth of the desired tree variety(2) there is adequate drainage of ground water (3) there are any environmental factors inherent to that location (such as wind-, soil- and dust-borne contaminants and pollutants) that might have a negative impact on safety concerns for human foods and (4) there is an available source of water suitable for irrigation and other purposes.

8. Neighbouring fields should not be used for plants which are known to be easily infected with *A. flavus/parasiticus* (e.g. maize) and consequently serve as a source of infection (spores spread by winds, insects, etc). Furthermore plants carrying specific insects that damage tree nut kernels, which may be a vector in the infection process, should also be avoided.

9. If the tree nuts are obtained from around cultivation, the picker should ascertain that there are not any environmental factors inherent to that location (such as wind-, soil- and dust-borne contaminants and pollutants) that might have a negative impact on safety concerns for tree nuts.

2.2 Planting

10. In designing the layout of the orchard, information concerning plant spacing may be obtained from plant breeders or agricultural personnel. Adequate spacing is necessary so that trucks and equipment needed for spraying trees can be accommodated and that ventilation of the orchard is maintained to reduce the growth of fungi.

11. Where possible and practical, the orchard surface area should be prepared before planting by destroying or removing all debris that may have served, or may potentially serve as substrates for the growth of mycotoxin-producing fungi. If there are areas vulnerable to soil erosion, no-till practices may be required in the interests of soil conservation.

12. Before planting, growers should consult with appropriate plant breeding authorities or tree nursery personnel to ascertain the availability of species that are resistant to various factors (e.g., frost, microbial and fungal diseases) that can have an impact on the safety and quality of nuts produced in the orchard.

13. Growers should be familiar with GAPs associated with the use of formulated fertilizers, manure and other biosolids that may be used to enhance the nutritional state of the soil, without increasing the risks of introducing hazards originating from microbial or fungal sources in the orchard.

14. Growers should consult with local or national authorities to determine insects and other pests that are commonly found in their region that might attack tree nuts causing them to be more susceptible to fungal infections that can lead to aflatoxin production.

15. Growers should take adequate precautions to ensure that human and animal wastes are disposed of in such a manner as not to constitute a public health or hygienic hazard, and take extreme care to protect the products from contamination with these wastes.

2.3 Preharvest

16. During the growing seasons, roadways near the orchards should be watered or oiled periodically to minimize outbreaks of mites as a result of dusty conditions. Cultivation practices, in the vicinity of the orchard, that might disperse *Aspergillus flavus/A. parasiticus*, and other fungal spores in the soil to aerial parts of trees should be avoided.

17. Pesticides approved for use on tree nuts, including insecticides, fungicides, herbicides, acaricides, and nematocides should be used to minimize damage that might be caused by insects, fungal infections, and other pests in the orchard and adjacent areas. Accurate records of all pesticide applications should be maintained.

18. Irrigation should be implemented in regions with high temperatures and very little rainfall during the growing season to minimize tree stress, however, irrigation water should be prevented from contacting the nuts and foliage.

19. Water used for irrigation and other purposes (e.g., preparation of pesticide sprays) should be of suitable quality, according to the legislation of each country, for the intended use.

20. All equipment and machinery, which is to be used for harvesting, storage and transportation of crops, should not constitute a hazard to health. Before harvest time, all equipment and machinery should be inspected to ascertain that they are clean and in good working condition to avoid contamination of the nuts with soil and other potential hazards.

21. Trade Associations, as well as local and national authorities should take the lead in informing growers of the hazards associated with aflatoxin contamination of tree nuts

and how they may practice safe harvesting procedures to reduce the risk of contamination by fungi, microbes and pests.

22. Personnel that will be involved in harvesting nuts should be trained in personal hygienic and sanitary practices that must be implemented in processing facilities throughout the harvesting season.

2.4 Harvest

23. Harvesting of nuts should begin as soon as practicable after maturation to minimize diseases caused by fungal attack and insect infestation. Some varieties of nuts become contaminated with aflatoxins while still on the tree as a result of insect infestation and hull splitting, therefore, the earlier the harvest, the less chance there is for contamination to occur because there is a greater chance that the outer hull will remain intact to protect the underlying shell from insects and fungal spores. The area under the trees should be cleared of any debris or decayed materials where A. flavus or A. parasiticus might reside.

24. Nuts, harvested by shaking the trees, should ideally be collected by mechanical harvesters with catching frames, or on some type of protective sheets or tarps under the trees to prevent nuts from falling to the ground. In regions where certain varieties of nuts are traditionally harvested by shaking the trees and/or allowing mature nuts to fall freely to the ground for collection by harvesting equipment or by hand, the orchard should not be used for grazing or holding cattle or other animals. If the land has been so used, the land should be worked immediately prior to harvesting (disced, rotilled, soil turned in some manner, or other feasible methods), to lesson the hazard of fecal contamination of tree nuts. In addition, procedures should be in place to ensure their removal as soon as possible to decrease exposure to *Aspergillus flavus/A. parasiticus* spores that may be denser in the air near the ground and associated with plant debris.

25. The nuts, after collection, should be sorted to remove damaged, rotten, empty and rancified nuts, foreign materials, and transported, as soon as possible, to a processing facility for immediate processing (hull removal) in containers (e.g., trucks, conveyers) that are clean, dry, protected against humidity and free of insects and visible fungal growth. High humidities, which are conducive to proliferation of mold and development of mycotoxins, should be avoided to the greatest extent practical. Conveyances for transporting nuts should be constructed of a material that will permit thorough cleaning and maintenance so as not to constitute a source of contamination for tree nuts. If the nuts cannot be transported immediately to a processing facility they should be temporarily stored in a way that will keep them dry and protected from rain, insects, rodents, birds and drainage of ground water.

2.5 Post-harvest

26. Nuts remaining on the trees after harvest should be removed during the winter months to reduce the over wintering of various insect populations.

27. Trees should be pruned and, when needed, treated with appropriate pesticides prior to each growing season.

28. The orchard floor or woodland should be cleared of litter and debris from the harvesting operations in order to decrease the colonization of *Aspergillus* fungi in the orchard or woodland.

29. Containers, equipment and machinery that have been used for harvesting operations should be cleaned and stored in a clean location to minimize inadvertent contamination with fungi, chemicals, fertilizers or toxic substances.

30. Harvesting and storage procedures implemented each crop year should be documented by making notes of measurements (e.g., temperature, moisture, and humidity) and any deviation or changes from traditional practices. This information may be useful for explaining the cause(s) of fungal growth and mycotoxin formation during a particular crop year and help to avoid similar mistakes in the future.

2.6 Processing

31. Personnel involved in all stages of tree nut processing should maintain a high degree of personal cleanliness, wear suitable protective clothing, be trained in food hygiene and general sanitation procedures to a level appropriate to the operations they are to perform in the processing facility. A system should be in place to ensure that all personnel remain aware of all precautions necessary to reduce the risk of aflatoxin contamination in the processing operations.

32. Areas where raw materials are going to be received or stored should be physically separated from areas in which final product preparation or packaging is conducted as to preclude contamination of the finished product. The hulling of nuts should be carried out in a location that is separated by partitions from the main processing area of the facility. Care should be taken to ensure that dust-laden air is not introduced into other areas of the facility through a vent system or other openings.

33. Processors should establish good quality control, traceability/product tracing and safety procedures at every step in the processing sequence to avoid cross contamination of aflatoxins between various lots of nuts during processing.

34. Hulling of nuts should begin as soon as possible after harvest. If a short delay in hull removal is anticipated, the nuts should be stored under conditions that will protect them from insects, mites, vermin, domestic animals, fungi, chemicals or microbiological contaminants, debris and dust. If a long delay is anticipated, nuts should be stored under controlled conditions to prevent aflatoxin production. If needed, appropriate fumigation could be used to control insects.

35. Dehulled nuts should be dried as soon as possible; the drying rate and heat intensity should be determined by the intended end use of the final nut product(s). The nuts should be dried to a safe moisture level that corresponds to a water activity, Aw, of less than 0.70 at 25 ºC. *Aspergillus flavus/A. parasiticus* cannot grow and produce aflatoxin at water activities less than 0.70. Dehulled nuts that are allowed to sun-dry are at a greater risk of becoming contaminated during the drying process as a result of fungal growth and/or damage by pests.

36. Moisture levels should be checked after drying by taking samples as representative of the lot as possible. Make sure that the equipment needed for moisture measurements is calibrated.

37. Mechanical driers should be available and used to reduce the potential of further aflatoxin contamination in regions where steam or aqueous solutions are traditionally used to facilitate dehulling, and segregation of defective nuts; the water used should be of suitable quality for intended use and never recycled.

38. Personnel and equipment used in the hulling/selection/preparation/drying/ storage areas of a processing facility should not enter into other areas of the facility; this will reduce the risk of contaminating other areas of the facility. Waste materials should be frequently removed from the working area during operation and adequate waste receptacles should be provided for the removal of the waste.

39. Various visual (manual) and/or electronic sorting techniques should be used to remove foreign materials and nuts with various defects. Nuts should not be used for processing unless they are free from obvious faecal contamination, infestations, decomposition and other defects. Special precautions must be taken to reject insect-damaged or early-split nuts because they are associated with a high risk of aflatoxin contamination.

40. For nut varieties that are traditionally preconditioned with moisture (steam or water of potable quality) to reduce kernel breakage during cracking, the moisture level of the kernels after cracking should be lowered immediately, to a level that will not support the growth of fungi by rapidly circulating dry air through the kernels.

41. The finished processed products (raw, shelled or in-shell, bulk or consumer ready) should be of the appropriate moisture and packaged so as to maintain their quality under normal transportation and storage conditions without significant deterioration by decay, mould, or enzymatic changes.

42. It is desirable that each plant has access to quality control facilities. The amount and type of such control will vary with different nut products as well as the needs of management. Some type of screening or recognized analytical procedure should be used to determine aflatoxin levels and preferable moisture content before products are released from the processing facility.

2.7 Transport of processed nuts to storage

43. Transport containers should be clean, dry, and free of visible fungal growth, insects and any contaminated material. The containers should be well constructed to withstand handling abuse without breaking or puncturing, and tightly sealed to prevent any access of dust, fungal spores, insects or other foreign material.

44. The nuts should be transferred from transport containers to the storage facility as soon as practicable. If different lots or sub-lots are transported together, they must be physically separated in a way that will ensure that identification of the lot is maintained. The lots must be indelibly marked with an identification number that can be traced back to the accompanying documentation (identification number of the lot must correspond to the identification number mentioned on the accompanying documents).

2.8 Storage

45. Storage facilities should be clean and dry (if possible keep the relative humidity < 70%), well-vented structures that provide protection from rain, entry of rodents and birds, drainage of ground water and have minimum temperature and humidity fluctuations. If possible, temperature should be kept between 0 ºC and 10 ºC to minimize fungal growth during storage.

46. Good storage practices should be implemented to minimize the levels of insects and fungi in storage facilities. This may include the use of suitable, registered insecticides and fungicides or appropriate alternative methods. Nuts stored in sacks should be placed on pallets which are positioned to allow good ventilation and access.

47. Water activity, which varies with moisture content and temperature, should be carefully controlled during storage. *Aspergillus flavus/A. parasiticus* cannot grow or produce aflatoxins at water activities less than 0.7.

48. Consideration should be given to fumigating nuts as they are removed from storage for export to control any storage pests that may be present and to prevent infestation during shipment.

3. SPECIAL CONDITIONS FOR SPECIFIC NUT SPECIES

3.1 Pistachio nuts

49. Pistachio nuts are exposed to airborne fungal spores while in the field, during harvesting and/or processing. When the nuts are still on the tree, sometimes the outer hull splits when the shell splits open (early-splits) and sometimes the hull is damaged by wind, insects or other pests. If insects or other pest damages the nut shell, then conditions exist for *Aspergillus* spores to invade and grow on the inner kernel and potentially produce aflatoxins.

50. During the growing season, growers should irrigate carefully and in good time to limit early splitting of the outer hull and reduce the risk of aflatoxin contamination. The mature nuts should be harvested early to reduce the chance for contamination since there is a greater chance that the outer hull will remain intact. The nuts should be delivered directly to the plant for hulling and drying within 24 hours of harvest to prevent shell staining.

3.2 Brazil nuts

51. Measures for the prevention and reduction of aflatoxin in Brazil nut are included as a separate appendix to this Code given the very specific conditions related to the Brazil nut collection and processing.

4. A COMPLEMENTARY MANAGEMENT SYSTEM TO CONSIDER IN THE FUTURE

52. The Hazard Analysis Critical Control Point (HACCP) system is a food safety management system that is used to identify and control hazards within the production and processing system. The general principles of HACCP have been described in earlier documents.[4,5]

53. The HACCP concept is an all-encompassing integrated management system. When properly implemented in the tree nut industry, this system should result in a reduction in the levels of aflatoxins observed in tree nuts. The use of HACCP as a food safety management system has many benefits over other types of management control systems used in some segments of the food industry. In orchards, many factors that influence aflatoxin contamination of

[4] FAO. 1995. The use of hazard analysis critical control points (HACCP) principles in food control. FAO Food and Nutrition Paper No. 58 Rome.

[5] ILSI, 1997. A simple guide to understanding and applying the hazard analysis critical control point concept, ILSI Europe Concise Monograph Series, 2nd edition, ILSI Europe, Brussels.

tree nuts are environmentally related, such as weather and insects; these are difficult or impossible to control. After harvesting, critical control points may be identified for aflatoxins produced by fungi during storage. For example, a critical control point could be at the end of the drying process and one critical limit would be the moisture content or water activity.

54. Good Agricultural Practices (GAPs), Good Manufacturing Practices (GMPs) and Good Storage Practices (GSPs) are programs that should be in place before attempts are made to establish and implement a HACCP system. A manual on the application of the HACCP system for mycotoxin prevention and control was recently published that included a plan developed for controlling aflatoxins in pistachio nuts in S.W. Asia[6]. It is recommended that tree nut producers, processors and others involved in the tree nut industry review this example, the concepts of which should be applicable to all tree nuts.

55. At the Third International Conference on Mycotoxins, which was held in Tunisia in March 1999, one of the general recommendations was that integrated mycotoxin control programs should incorporate HACCP principles in the control of risks associated with mycotoxin contamination of foods and feeds[7]. The implementation of HACCP principles will minimize aflatoxin contamination through applications of preventive controls to the extent feasible in the production, handling, storage and processing of each tree nut crop. Since all countries may not have the required technical expertise and experience to establish effective integrated mycotoxin management systems, the Food and Agriculture Organization (FAO) has given high priority to the provision of training professionals in developing countries on the HACCP approach and its application.

[6] FAO/IAEA training and reference center for food and pesticide control, 2002. Manuel on the Application of the HACCP System in Mycotoxin Prevention and Control. FAO Food and Nutrition Paper No. 73, Rome.

[7] FAO. Preventing Mycotoxin Contamination. Food, Nutrition and Agriculture No. 23, 1999. Food and Nutrition Division, FAO, Rome.

APPENDIX

ADDITIONAL MEASURES FOR THE PREVENTION AND REDUCTION OF AFLATOXIN CONTAMINATION IN BRAZIL NUTS

INTRODUCTION

1. The formulation and acceptance of an appendix to the Code of Practice for the Prevention and Reduction of Aflatoxins Contamination in Tree Nuts will provide uniform guidelines for producing countries to consider in attempting to control and manage contamination of Brazil nuts by aflatoxins. In order for these measures to be effective, it will be necessary for collectors, processors and other members of the production chain to consider the general principles established by the Code, while taking into account the fact that the Brazil nut tree (*Bertholletia excelsa*) is not cultivated. This species exists all over the Amazon Region however the largest concentrations of trees are in the Brazilian Amazon.

2. This appendix applies only to Brazil nuts, given the very specific conditions related to their collection and processing.

RECOMMENDED PRACTICES BASED ON GOOD EXTRACTIVISTIC PRACTICES (GEP)

Pre-collection

3. The extractivists should clear the area under the Brazil nut trees, removing residual pods and nuts from the former crop. Pods left from the last crop season should never be mixed with pods from the present crop season, as they represent a potential source of contamination with *Aspergillus*.

Collection

4. Collection should proceed continuously as soon as possible after the pods have fallen from the trees. A certain delay in the collection is expected because during the crop season remaining pods may fall, posing a risk to the lives of the collectors.

5. Pods should be sorted to remove damaged ones and gathered in piles, if possible, in thin layers, for only a short period of time (preferably less than 5 days).

Post collection

6. Pods should be opened as soon as possible after collection, with the nuts being removed and separated from the pods and placed on a clean and dry floor or plastic canvas in good condition, to avoid contact with the soil. During the opening of the pods care should be taken to avoid damage to the nuts as much as possible. The nuts should be sorted to remove damaged and empty ones.

7. Initial transportation of the nuts, from the forest to a storage facility, should occur as soon as possible, using containers that are clean, dry and protected against rain and insects, to the greatest extent possible.

8. To avoid aflatoxin formation the nuts should be dried to a safe moisture level corresponding to a water activity below 0.70 preferably within 10 days from the collection. Sun-drying is normally not sufficient to reach a safe moisture level due to the high relative humidity in the rain forest environment. This recommendation is particularly important when producing Brazil nuts to be traded as “in-shell” where contaminated nuts are difficult to distinguish from sound nuts without cracking the nut. The nuts should be protected against rain and pests, such as birds, rodents and insects and any other source of contamination.

9. After drying, the nuts should be placed in a storage facility with a floor at least 50 cm above ground level; protected against rain and pests and that allow good air circulation. For the purpose of identification and traceability, nuts, in bulk or in bags, from different origins and/or days of collection should preferably be handled separately and kept separated until the final processing and packaging.

10. During the transportation of the nuts from the primary storage facility, in bulk or in bags, either to an intermediate location or to a processing facility, the nuts should be separated from other goods, in containers that are clean, dry, protected against humidity and free from insects and visible fungal growth. Conveyances for transporting nuts should be made of material that will permit thorough cleaning and maintenance so as not to constitute a potential source of contamination for the Brazil nuts.

11. If the nuts are stored at an intermediate location, before reaching the processing facility, the storage facility should have the following:

a) protection from rain and pests;
b) a washable and impermeable floor;
c) drainage of ground water;
d) good air circulation;
e) sufficient area and proper divisions to allow separation of lots.

This intermediate storage is only recommended if the moisture content of the nuts corresponds to a water activity below 0.70. Otherwise no intermediate storage is recommended, especially for nuts expected to be marketed in-shell.

GENERAL RECOMMENDATIONS

12. National, State and local governments, as well as Non Governmental Organizations – NGOs, trade associations and cooperatives should provide basic education and update information on the hazards associated with aflatoxin contamination to the agents involved in the Brazil nuts production chain.

13. Local people (extractivists) involved in the collection of Brazil nuts should be regularly trained in personal hygienic and sanitary practices that must be implemented at all stages of production including the pre-collection, collection, post-collection and processing.

14. It is recommended that further development and validation of the current quality control system, used in most processing plants, by checking the percentage of “bad” nuts in the incoming lots be undertaken. This method may be used as a tool for decision if a lot can be commercialized as “in-shell” nuts or should be shelled and sorted to eliminate the bad nuts.