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World Health Organization

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CODEX COMMITTEE ON CONTAMINANTS IN FOODS

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REVISION OF THE CODE OF PRACTICE FOR THE PREVENTION AND REDUCTION OF AFLATOXIN CONTAMINATION IN PEANUTS (CXC 55-2004)

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

Codex members and observers wishing to submit comments at Step 3 on the revised *Code of practice for the prevention and reduction of aflatoxin contamination in peanuts* should do so as instructed in CL 2025/13-CF, available on the Codex webpage[1]

BACKGROUND

1. Aflatoxins (AFs) are the most potent liver carcinogens known, based on studies in test species and human epidemiological studies, as classified by the 49th and reaffirmed by the 83rd meeting of the Joint FAO/WHO Expert Committee on Food Additives (JECFA)[1]. Moreover, aflatoxins have acute, chronic, genotoxic, carcinogenic, and immunosuppressive properties. Several species of *Aspergillus* section *Flavi-producing aflatoxins have been described, but the most common in food are Aspergillus flavus, A. parasiticus,* and *A. nomius* and related species.

2. Given the importance of reducing aflatoxin exposure from peanuts, in 2004, the Codex Alimentarius Commission (CAC) adopted a *Code of practice for the prevention and reduction of aflatoxin contamination in peanuts*. The code of practice (CoP) includes recommended practices for reducing aflatoxins at the pre-harvest, harvest, transport, storage, and manufacturing stages.

3. The 49th JECFA Meeting (JECFA49, 1998)[2] evaluated AFs (B1, B2, G1, and G2; AFT) and concluded that aflatoxins are human liver carcinogens, with AFB1 being the most potent. Since aflatoxins were considered genotoxic carcinogens, no tolerable daily intake was proposed. Thus, adopting the ALARA Principle (As Low As Reasonably Achievable) was recommended to reduce the potential risk. JECFA83 (2017)[3] re-evaluated toxicological data and dietary exposure to AFs and reaffirmed the conclusions of JECFA49.

4. The work undertaken by the Codex Committee on Contaminants in Foods (CCCF) on reviewing Codex standards for contaminants produced an "Overall Highest Priority List of Codex Standards and Related Texts for Contaminants in Food and Feed," which identified the highest need for reviewing existing standards and related texts developed by CCCF. At the 16th Session of the Codex Committee on Contaminants (2023), the CoP was identified as a high priority for review[2].

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1 Codex webpage/Circular Letters:
http://www.fao.org/fao-who-codexalimentarius/resources/circular-letters/en/.
Codex webpage/CCCF/Circular Letters:
http://www.fao.org/fao-who-codexalimentarius/committees/committee/related-circular-letters/en/?committee=CCCF

2 https://www.who.int/publications/i/item/9241208848

3 https://www.who.int/publications/i/item/9789241210027

5. Because aflatoxin exposure from peanuts continues to be a public health concern and new information is available on reducing aflatoxins in peanuts, CCCF16 agreed to establish an Electronic Working Group (EWG) chaired by Brazil to develop a discussion paper to explore whether there were new measures supporting a revision of the *Code of practice for the prevention and reduction of aflatoxin contamination in peanuts* (CXC 55-2004).

6. CCCF 17 (2024) agreed to (i) start new work on the revision of the *Code of practice for the prevention and reduction of aflatoxin contamination in peanuts* (CXC 55-2004); (ii) forward the project document to the 47th Session of the Codex Alimentarius Commission (CAC47) for approval; and (iii) establish an EWG, chaired by Brazil and co-chaired by India, to prepare a revised CoP for comments and consideration by CCCF18.[4] CAC47 (2024) approved this new work.[5]

WORK PROCESS

5. Two drafts of the revised CoP were circulated in the EWG through the Codex Forum. Comments were received from Australia, Cabo Verde, Canada, Costa Rica, Indonesia, Iran, Japan, the Netherlands, Nigeria, and the United States of America (USA) and were considered in revising the document.

6. The proposed revised *Code of Practice for the Prevention and Reduction of Aflatoxin Contamination in Peanuts (CXC 55-2004) is available in Appendix I. For information, references supporting the revised provisions in the CoP are listed in Appendix II*. The list of participants is available in Appendix III.

KEY POINTS OF DISCUSSION

7. Practices already included in CXC 55-2004 were not modified unless new information is available based on literature-supported adjustment. However, editorial changes were made throughout the document. During the EWG discussions, the following conclusions were made based on comments received from members:

- "Introduction" and "General recommendations" sections were included to summarize aspects of forming aflatoxins, the main aflatoxigenic species in peanuts, and practices that apply to several stages of peanut production. A "related Codex texts" section was included to refer to the main Codex texts directly related to the CoP and should be considered together.
- Definitions were revised, aligning with other definitions in Codex texts and including additional relevant definitions to the CoP.
- Feed was included in the scope as requested by some Codex members, considering that peanut by-products could be destined for feed and aflatoxin contamination may be a concern.
- Measures identified in the literature by Codex members were included if they related to preventing or reducing aflatoxin contamination in peanuts.
- Information not directly relevant to aflatoxin production in peanuts was removed from the CoP, such as practices to avoid soil erosion or the need to use suitable water for irrigation.
- Post-harvesting subsections were included in the Good Manufacturing Practices (GMP) section, as they are more relevant to peanut processing than harvesting. Meanwhile, Good Agricultural Practices (GAP) were maintained separately, focusing on the pre-harvesting and harvesting stages of peanut cultivation.
- A table was included to elucidate the stages of peanut reproductive growth, demonstrating the full maturity stage when harvesting is optimal. Immature or overmature kernels may be highly contaminated, and understanding peanut development is directly related to aflatoxin formation.
- Different views were expressed related to the moisture content that peanuts should achieve after the first and second drying. One member requested to align with the *Standard for peanuts* (CXS 200-1995) that defines maximum moisture content levels of 10% for peanuts in-pod and 9.0% for peanut kernels. The Standard also says that "lower moisture limits should be required for certain destinations in relation to the climate, duration of transport and storage." In tropical regions, a moisture content of 9.0% may not be safe as aflatoxins can still be produced due to high environmental temperatures. Therefore, a moisture content of 8.0% is considered more suitable for peanut kernels.
- A new section includes information on the effect of roasting as one important process that can reduce aflatoxin contamination.

4 REP24/CF17, paras. 120-123, Appendix VIII

5 REP24/CAC47, para. 169 and Appendix V.

- The section "A complementary management system to consider in the future" was replaced by "risk management for aflatoxin control in peanut chain." The text was revised for clarity, and examples were added to illustrate the practices effectively.

CONCLUSIONS

8. The EWG concluded that all relevant revisions had been made based on the current information at hand, and the revised CoP is for consideration and advancement in the step process.

RECOMMENDATIONS

9. CCCF is invited to:

(i) consider the revised *Code of practice for the prevention and reduction of aflatoxin contamination in peanuts* (CXC 55-2004) in Appendix I, in particular, those sections that have been technically revised or added, namely:

- Revised Sections
  - Scope
  - Definitions
  - Recommended practices based on good agricultural practices (GAP)
  - Recommended practices based on good manufacturing practices (GMP)
  - Risk management for aflatoxin control in the peanut chain
- Additional Sections
  - Introduction
  - Related Codex Texts
  - General recommendations

(ii) advance the Code of practice in the Step Procedure for adoption by CAC48.

APPENDIX I

PROPOSED REVISED CODE OF PRACTICE FOR THE PREVENTION AND REDUCTION OF AFLATOXIN CONTAMINATION IN PEANUTS (CXC 55-2004)

(For comments at Step 3)

1. INTRODUCTION

1. As demonstrated by research, Aflatoxins (AF) are among the most potent liver carcinogens. This classification was established by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) at its forty-ninth meeting and reaffirmed at its eighty-third meeting, based on studies in test species and human epidemiological studies. In addition to their carcinogenic properties, aflatoxins exhibit acute and chronic toxicity and genotoxic, carcinogenic, and immunosuppressive effects. Aflatoxins can be found in several food commodities, including peanuts, tree nuts, dry figs, cereals, spices, and derived products.

2. Several species of the *Aspergillus* section *Flavi* are known to produce aflatoxins, with *Aspergillus flavus, A. parasiticus,* and related species commonly isolated from peanuts. These fungi are usually found in soils where peanuts grow and can infect them under favourable conditions. The interaction of the host plants, the fungus, and the environment determines the infection of the peanut and the subsequent aflatoxin production. Pre-harvest conditions such as drought stress, elevated temperatures, and humidity during seed filling and plant development are among the most important factors that influence aflatoxigenic fungal infection and aflatoxin production.

3. After harvest, peanuts are cured, often sun-dried, stored, and traded. To prevent aflatoxigenic species growth and toxin formation, the water activity and/or moisture content of peanuts can be monitored and maintained. Colour sorting, blanching, and roasting are processing stages that can contribute to aflatoxin reduction in the peanut production chain.

2. SCOPE

4. This document is intended to provide guidance for all parties involved in producing/processing and handling peanuts for international trade intended for food and feed. Peanuts should be prepared and handled in accordance with the *General principles of food hygiene* (CXC 1-1969) and the *Code of hygienic practice for groundnuts (peanuts)* (CXC 22-1979), which apply to all foods prepared for human consumption. These outline the measures that should be implemented by those responsible for ensuring that food is safe and suitable for consumption.

3. RELATED CODEX TEXTS

- *General standard for contaminants and toxins in food and feed* (CXS 193-1995)
- *Recommended methods of analysis and sampling* (CXS 234-1999)
- *General principles of food hygiene* (CXC 1-1969)
- *Code of hygienic practice for groundnuts (peanuts)* (CXC 22-1979)
- *Standard for peanuts* (CXS 200-1995)
- *Code of practice for the reduction of aflatoxin b1 in raw materials and supplemental feedingstuffs for milk-producing animals* (CXC 45-1997)

4. DEFINITIONS

- **Blows (Pops)**: In-shell peanuts, which are unusually light in weight due to extensive damage from physiological, mould, insect, or other causes and which can be removed, for example, by an air-separation process.
- **Curing**: Drying of the in-shell peanuts to a safe moisture level.
- **Extension services**: The entire set of organizations that facilitate and support people engaged in agricultural activities to solve problems and to obtain information, skills, and technologies to improve their livelihoods and well-being.
- **Farmer's stock**: In-shell peanuts as they come from farms.
- **Moisture content**: A measure of water content in a product.
- **Peg**: An ovary stalk that goes underground and where the pods originate from.

- **Water activity (aw)**: Commonly defined in foods as the water that is not bound to food molecules that can support the growth of bacteria, yeasts, and fungi.
- **Xerophilic fungi:** Fungi that can grow at low water activity, below 0.85, under at least one set of environmental conditions.

5. GENERAL RECOMMENDATIONS

5. Document the harvesting, drying, cleaning, and storage procedures and conditions (e.g. temperature, moisture, humidity, pH, oxygen) each season to help identify causes of fungal growth and prevent future occurrences. Validated predictive models can be useful in helping make management decisions.

6. Before use and re-use, ensure all equipment and materials used for planting, harvesting, transporting, drying, cleaning, and storage are:
   - cleaned of potential sources of contamination (e.g. crop residues, dust, insects, fungal growth, broken glass, animal excrement) and dried. Use approved cleaners and disinfectants that do not cause off-odours, flavour, or contaminate the crop.
   - intact and able to provide protection from water (e.g. precipitation, groundwater seepage, condensation) as well as rodents, birds, and insects that can contaminate the crop and cause physical damage, making it more susceptible to mould infection. Use registered fumigants or insecticides as needed.

7. Ensure all equipment and materials used for planting, harvesting, transporting, drying, cleaning, and storage are in good working order and calibrated to relevant conditions (e.g. moisture sensors), where applicable. Have spare parts available to minimize time loss for equipment repairs.

8. Aim to minimize mechanical damage to crops during cultivation, irrigation, pest management practices, harvest, and cleaning.

9. Contact product or equipment manufacturers, competent authorities, and/or extension services for supplementary information about the practices noted in this code of practice.

10. Extension services can advise about aflatoxin mitigation measures relevant to regional conditions and situations.

11. Products used in the production of food and animal feed that may indirectly prevent or control aflatoxin-producing species (e.g. insecticides, additives used to support fermentation) or directly reduce aflatoxin levels post-harvest (e.g. additives, mycotoxin detoxifying agents (MDAs) should be approved/registered and used within the parameters set by competent authorities. Such products should also be straightforward to use, affordable, and effective for their intended purpose when applied following the manufacturer's instructions. Post-harvest aflatoxin reduction measures are an area of further study.

12. Aflatoxin B1 concentrations in food and feed may be heterogeneous. Therefore, it is important that any sampling and testing follow Codex sampling plans or those of competent authorities to provide accurate and representative results.

6. RECOMMENDED PRACTICES BASED ON GOOD AGRICULTURAL PRACTICES (GAP)

6.1 Preparation for planting

13. For effective pre-harvest control of aflatoxin contamination in peanuts, it is essential to consider all the environmental and agronomical factors that influence pod and seed infection by the aflatoxigenic fungi, and aflatoxin production. These factors can vary considerably from one location to another and between seasons in the same location. Some conditions may be particularly favourable to fungal infection and subsequent aflatoxin contamination of peanuts. In these circumstances, appropriate planning and agricultural practices should be employed to reduce aflatoxin contamination in peanuts.

14. The cultivation of peanuts on the same land for several cycles may lead to a build-up of high populations of *A. flavus* and/or *A. parasiticus* in the soil, increasing the probability of infection and aflatoxin contamination. Some studies have been carried out on the effect of crop rotation on aflatoxin contamination. In semi-arid environments, populations of aflatoxigenic fungi may be very high, and crop rotations have little influence on the activity of these species. Cropping systems in some regions involve diverse cultivation and fertilizer practices that, individually or taken together, may affect the survival or build-up populations of the aflatoxigenic fungi. There is evidence that peanuts grown in different soil types may have significantly different infection levels by the fungi. Light sandy soils, for example, favour rapid proliferation of the fungi, particularly under dry conditions. In contrast, heavier soils have a higher water-holding capacity and, therefore, there is less likelihood of drought stress, which may partly explain the lower-than-average levels of aflatoxin contamination in peanuts grown on such soils.

15. Use soil test results to determine if fertilizer and/or soil conditioners are needed to maintain appropriate soil pH and plant nutrition. This helps prevent plant stress, especially during seed development, when peanuts are more susceptible to fungal infection. Utilizing soil amendment such as composting manure and gypsum/lime at sowing time is shown to reduce *A. flavus* seed infection and aflatoxin formation. Lime and gypsum are sources of calcium that enhance cell thickness and pod filling and decrease fungal infection while also altering soil pH. Organic supplements, such as composting manure and crop residues, improve the soil's water-holding capacity, minimizing the effect of drought during plant development and reducing fungal infection and aflatoxin accumulation in the peanut seeds.

16. The choice of peanut variety is important, so before planting, farmers should consult with the appropriate plant breeding authorities or extension services to identify the cultivars most suitable for their region. They should also consider the availability of varieties resistant to various factors, such as insect infestation and fungal and other microbial infections, which can affect the safety and quality of the peanuts. A cultivar that is suitable for a particular growing season and matures at the end of the rainy season should be selected, allowing post-harvest field drying under favourable conditions. It is undesirable that a variety suffers from drought stress during pod maturation; therefore, some adjustments may have to be implemented to avoid such stress. Cultivation strategies may be considered, which maximize harvest during dry conditions while preventing drought stress as much as possible (e.g. the use of early ripening cultivars that mature before the rainy season has ended).

17. It is essential to prevent the overcrowding of plants by adhering to the recommended spacing between rows and within plants for the specific species or varieties being cultivated. Establishing optimal plant populations is crucial, as excessively high densities can result in drought stress, particularly in seasons where rainfall is not at ideal levels needed for growth.

6.2 Pre-harvest

18. When necessary, irrigation may be used as a strategy to mitigate the impact of heat and drought stress. Water stress affects plants in three ways: first, by wilting the plant and reducing its metabolic activity, which inhibits the plant's natural defences against fungal infection; second, by lowering the water activity in the soil, which reduces growth and activity of competing microorganisms; and third, by promoting the growth of *A. flavus* or *A. parasiticus*, which are xerophilic fungi.

19. Irrigation to ensure adequate soil moisture during the pod/seed filling and before harvest should minimize pre-harvest aflatoxin contamination of peanuts. This may be achieved by growing a thoroughly irrigated crop or applying supplementary irrigation to a rain-fed crop. If irrigation is used, ensure that it is applied evenly and that all plants in the plot have an adequate water supply.

20. Excessive weed growth may affect available soil moisture. Effective weed control by the use of registered herbicides or cultivation is therefore advisable. During weed cultivation, care should be taken to avoid damaging pegs and pods.

21. Cultivation and crop protection practices that lower the incidence of soil insects, mites, and nematodes can help reduce aflatoxin contamination. Minimizing insect damage and fungal infection in the vicinity of the crop can be achieved by the proper use of registered insecticides, insect-resistant cultivars, fungicides, and other appropriate practices within an integrated pest management program. Growers should consult local or national authorities and extension services to identify the insects and pests commonly found in their region that may attack peanuts, making them more susceptible to fungal infections and aflatoxin production.

22. No fungicide, combinations of fungicides, or other chemical treatments appear to have been widely adopted for the practical control of *A. flavus* or *A. parasiticus* infection and subsequent aflatoxin contamination of peanuts pre-harvest. The results of studies on the application of fungicides on freshly harvested or windrowed peanuts are equivocal.

23. Biological methods could be used, like biofungicides and biopesticides. For example, the deliberate introduction of competitive, non-aflatoxigenic *A. flavus* and *A. parasiticus* into the agricultural environment can suppress the natural occurrence of the aflatoxigenic fungi. Any applied product must be approved by competent authorities, straightforward to use, affordable, and effective towards the targeted toxin-producing fungi when applied following the instructions of the manufacturer.

6.3 Harvest

24. Local and national authorities, as well as trade associations, should take the lead in informing growers of the hazards associated with aflatoxin contamination of peanuts and how they may practice safe harvesting procedures to reduce the risk of contamination.

25. Personnel involved in harvesting peanuts should be well-trained in the personal hygienic and sanitary practices that must be followed throughout the harvesting season.

26. Ensure all equipment intended for harvesting and storage is fully functional. A breakdown during this critical period may cause peanut quality losses and increase the risk of aflatoxin formation.

27. Peanuts must be harvested at full maturity (R8, as shown in Table 1) unless there are chances of extreme heat, rainfall, or drought conditions. It is very important to harvest the crop at optimal maturity, as excessive numbers of over-mature pods at harvest can be reflected in high levels of aflatoxin in the product. Delayed harvest of peanuts may cause a significant increase in the aflatoxin content of infected plants (or peanuts). Monitoring crop maturity, precipitation, and soil temperature, as well as the use of predictive models, if available, may be very useful in helping target optimal harvest periods.

28. Immature pods are more likely to be contaminated by aflatoxins due to lower phytoalexin levels, which give natural resistance to fungal infection.

29. Table 1 represents the stages of peanut reproductive growth. The following stages correspond to the beginning of pod formation (R3), pod expansion (R4), and seed formation (R5). Once it reaches the ground, the peg with its swollen ovary doubles its width, and the expansion of the pod begins. With the pod fully expanded, the growth of the seed's cotyledon begins. Seed formation begins approximately 60 days after planting. When the pod cavity is completely filled with seed, the plant reaches the R6 stage around 74 days after planting. When 50% of the plants have at least one pod that shows colour on the inner part of the pericarp, the plantation reaches the R7 stage, indicating the beginning of maturation. Complete maturation (R8), indicating the moment of harvest, occurs when 70 to 75% of the pods are placed in the inner part of the pericarp. Stages R7 and R8 occur approximately in the last 30 days of the peanut planting cycle. Maturation can be observed by the colour of the cotyledons, which varies from white (immature kernels) to pink (more mature kernels).

Table 1. Stages of peanut reproductive growth.

Stage	Reproductive stages	Description	Figure
R1	Beginning bloom	One open flower at any node on the plant.	
R2	Beginning peg	One elongated peg (gynophore).	
R3	Beginning pod	One peg in the soil with turned swollen ovary at least twice the width of the peg.	
R4	Full pod	One fully expanded pod, to dimensions characteristic of the cultivar.	
R5	Beginning seed	One fully expanded pod in which seed cotyledon growth is visible when the fruit is cut in cross-section.	

Stage	Reproductive stages	Description	Figure
R6	Full seed	One pod with cavity apparently filled by the seeds when fresh.	
R7	Beginning maturity	One pod sharing visible natural coloration or blotching of inner pericarp or testa.	
R8	Harvest maturity	66-75% of all developed pods have testa or pericarp coloration.	
R9	Over-mature pod	One undamaged pod showing orange-tan coloration of the testa and/or natural peg deterioration	

30. Individual plants that die due to damage from pests, pathogens, such as *Sclerotium rolfsii* or *Fusarium* spp., and diseases, like rosette virus, or insects, such as termites, earwigs, and false wireworms that cause damage to the pods, should be harvested separately, if possible, as peanuts from these plants are likely to be contaminated with aflatoxins.

31. If irrigation systems are used, care should be taken to harvest peanuts beyond the reach of irrigation systems separately to avoid mixing peanuts from irrigated sections with those from unirrigated sections.

32. Damage to peanut pods at the time of harvest should be avoided as much as possible since this can lead to rapid invasion of the pods by *A. flavus* or *A. parasiticus*. Peanuts should be handled as gently as possible, with every effort to minimize physical damage at all harvesting stages and transportation procedures.

33. After harvest, peanut pods should be exposed to sun and wind for maximum drying rate. This may be accomplished by turning the plants to leave the pods uppermost, away from the ground, and exposed to sun and wind. Curing should be completed as soon as possible to a safe water activity to prevent the growth of microorganisms, particularly aflatoxigenic fungi. However, curing too rapidly may cause skin slippage and off-flavours of the peanut kernels. When curing by supplemental heat, excessive heat should be avoided since this impairs the general quality of the peanuts, e.g. causing the splitting of kernels after shelling. Close checks of moisture content/water activity of lots of farmer's stock peanuts should be maintained.

34. Peanuts should be dried so that damage to the peanuts is minimized and moisture levels are lower than those required to support fungal growth during storage. The ideal combination of moisture level and maximum allowed drying period will vary with peanut variety and agricultural zone. It is envisaged that the preliminary windrow drying should achieve a moisture level of < 12%, whereas the second drying phase, on a flat surface or by other suitable methods, should attain a moisture level of <10% for peanuts in-pod and <8% for peanuts kernels. Lower moisture limits should be required for certain destinations in relation to the climate, duration of transport and storage.

35. Freshly harvested peanuts should be cleaned and sorted to remove damaged peanuts and other foreign matter. Cleaning procedures such as density separators or air legs to remove light pods and slotted screens to eliminate pre-shelled kernels may remove some infected peanuts.

7. RECOMMENDED PRACTICES BASED ON GOOD MANUFACTURING PRACTICE (GMP)

7.1 Transport to Processing Facilities

36. The farmer's stock peanuts should be transported to a suitable storage facility or to the processing area for processing as soon as possible after harvesting or drying.

37. Vehicles (e.g. wagons, trucks) to be used for collecting and transporting the harvested peanuts or farmer's stock from the farm to drying facilities or storage facilities after drying should be clean, dry, and free of insects and visible fungal growth before use and re-use.

38. Transport containers should be dry and free of visible fungal growth, insects, and any contaminated material. As necessary, transport containers should be cleaned and disinfected before use and re-use and be suitable for the intended cargo. The appropriate use of registered fumigants or insecticides may be helpful. At unloading, the transport container should be emptied of all cargo and cleaned as appropriate.

39. Consignments of farmer's stock peanuts should be protected from additional moisture by using covered or airtight containers or tarpaulins but remove them promptly after transportation to avoid moisture trapping, which could make the consignment more conducive to mould growth and aflatoxin contamination. Avoid temperature fluctuations that may cause condensation on the farmer's stock peanuts, which could lead to local moisture build-up and consequent fungal growth and aflatoxin formation.

40. Avoid insect, bird, and rodent infestation during transportation using pest-proof containers or insect and rodent-repellent chemical treatments if they are approved for the intended use.

7.2 Segregation of aflatoxin-contaminated lots

41. The results from the investigations indicate that quality sorting removes a large part of the aflatoxin present at harvest. The distribution of aflatoxins in a lot of peanuts is heterogeneous, and consequently, following an appropriate sampling plan is critical. The sampling plan for total aflatoxins in peanuts is established in the *General standard for contaminants and toxins in food and feed* (CXS 193-1995).

42. Farmer's stock peanuts should be screened for aflatoxin contamination to segregate for proper storage. Aflatoxin-free loads should be segregated from loads with low levels of aflatoxin contamination, loads destined for subsequent processing and clean-up, and loads that are highly contaminated.

7.3 Storage of in-shell peanuts

43. The post-harvest storage phase is crucial for controlling aflatoxin contamination in peanuts.

44. A properly ventilated warehouse with a roof of suitable material and a concrete floor is required to prevent the rewetting of peanuts. Ensure that the storage facilities include dry, well-ventilated structures that protect from rain, groundwater drainage, protection from the entry of insects, rodents, and birds, and minimum temperature fluctuations. Also, the following are examples of warehouse improvements proven to be effective: (1) Painting warehouse roofs with white paint reduces solar heat load when compared to conventional galvanized material, and (2) The double roofing concept of installing a new roof over a defective, existing roof, with an air space in-between the two roofs, has proven effective in controlling warehouse condensation.

45. Moisture content and temperature of peanuts should be carefully monitored during storage.

46. Uniform loading in the warehouse allows excessive heat and moisture to escape and reduces areas favourable for insect infestation. Stockpiling of peanuts can cause heat build-up and moisture accumulation, causing mould growth and aflatoxin contamination.

47. The increase in aflatoxin contamination during storage and transportation depends on water activity and moisture content, the temperature in the environment, and the hygienic conditions. *A. flavus* and *A. parasiticus* cannot grow or produce aflatoxins at water activities less than 0.7 and moisture content less than 8-9%. Relative humidity below 70% and temperatures between 0 °C and 10 °C are optimal for minimizing spoilage and fungal growth during long-time storage.

48. Store at the lowest temperature possible, consistent with ambient conditions, but avoid near-freezing temperatures. Where possible, aerate the peanuts by circulating air through the storage area to maintain proper and uniform temperature levels throughout the storage area.

49. Aflatoxin levels in farmer's stock peanuts coming into and out of storage should be monitored for aflatoxins using appropriate sampling and screening techniques, such as rapid tests that report acceptable/not acceptable results.

50. For bagged peanuts, ensure that the bags are clean and dry and stacked on pallets, or incorporate a water-impermeable layer between the bags and the floor.

51. Measure the temperature, when possible, of the stored peanuts at scheduled intervals during storage. Increasing temperature is likely a good indicator of microbial growth as well as insect infestation. Visually check peanuts for evidence of mould growth and insect damage. Separate the apparently infected peanuts and send samples for analysis if possible. When separated, lower the temperature of the remaining peanuts and aerate. Avoid using visually infected peanuts for food or feed production.

52. Use good 'housekeeping' procedures to minimize the levels of insects and fungi in storage facilities. This may include the use of suitable traps, registered insecticides, fungicides, and fumigants. Any product applied must be approved by competent authorities, following the instructions of the manufacturer.

53. Record the harvesting and storage procedures employed each season and document measurements of temperature, moisture levels, water activity, and humidity, along with any deviations or alterations from conventional practices. This information may be very useful for explaining the causes of fungal growth and aflatoxin contamination during a particular crop year and help to avoid similar issues in the future.

7.4 Receiving and shelling

54. A buyer for a shelling plant, whether located at the plant or an outlying buying point, should monitor the quality of peanuts offered and assist suppliers in eliminating improper practices. Buyers should encourage farmers' stock peanuts suppliers to follow Good Agricultural Practices (GAP) as described herein, including application and documentation of good agricultural practices, quality assurance, and quality control measures.

55. Farmers' stock peanuts received at the shelling plant should be inspected on arrival. It is advisable to know the origin and history of each lot of peanuts. The transport vehicle should be examined. If the vehicle is not fully enclosed, it should have a covering such as tarpaulin to keep out rain or other forms of water. The general appearance of the peanuts should be observed during the process of unloading. If the peanuts are wet to the touch, they should not be mixed with peanuts in a bulk warehouse. The vehicle that contains the peanuts should be set aside until a decision is made for their disposal. If possible, remove a sample from each lot, separate the "loose shelled" kernels, and shell the remainder for peanut grade observation before an acceptance decision is made.

56. Specifications for the purchase of peanuts intended for further processing should include a maximum level for aflatoxins based on appropriate sampling and analysis methods.

57. Peanuts showing signs of insect damage or mould growth must be rejected because of the higher risk of aflatoxin contamination. Aflatoxin test results should be known before allowing lots of raw peanuts to be processed. Any lot of raw peanuts with unacceptable levels of aflatoxins, which cannot be reduced to permitted levels by the available sorting equipment, should not be accepted.

58. Suppliers of shelled peanuts should comply with the processor requirements to ensure that the finished product meets all specifications, including the maximum limit for aflatoxins.

59. Examine all loose-shelled, damaged "Blows" and undersized kernels for possible presence of mould. If no external mould is visible, split the kernels to disclose possible hidden mould growth. Excessive mould or the presence of mould resembling *A. flavus* warrants a chemical test for aflatoxin or rejection of the lot.

7.5 Sorting

60. Several peanut processing procedures, such as sorting, density flotation, blanching, and roasting, have been shown to reduce aflatoxin levels by up to 99%. Aflatoxins can be reduced at any stage of production by removing defective peanuts and foreign matter by sorting (electronically or manually), winnowing, separating by gravity or other methods. Sorting is the final step for removing defective kernels.

61. In electronic or laser sorting, each shelled peanut is inspected, and discoloured peanuts are removed, as discoloration often indicates fungal growth and potential aflatoxin contamination. Sorting can reduce up to 70% of aflatoxin. In addition to electronic or laser sorting based on the appearance of kernels, utilizing equipment that can remove kernels with internal defects through differences in near-infrared transmittance has shown to be an effective method for reducing aflatoxin levels.

62. In the case of manual sorting, belts should be well lit, with peanuts passing through no more than one-layer deep and operated at a speed that enables hand sorters to ensure effective removal of foreign material and defective kernels. Sorting machines should be adjusted as often as practicable against standards to ensure the removal of all defective kernels. Adjustments should be checked frequently and regularly.

63. To remove mould-contaminated peanuts effectively, sorting should be performed before and after blanching and roasting. Where splitting is part of the processing operation, kernels that resist splitting should be removed. The effectiveness of sorting techniques should be checked by regular aflatoxin analyses of the sorted peanuts, or in the finished product, or both. This should be done frequently enough to ensure the product is completely acceptable.

64. Defective kernels (mouldy, discoloured, rancid, decayed, shrivelled, insect, or otherwise damaged) should be bagged separately and tagged as unsuitable for human consumption. Containers of defective peanuts should be removed from the processing area as soon as possible. Peanuts possibly contaminated or contaminated with aflatoxins based on previous analysis should be redirected to oil production, non-food, or feed uses, if acceptable standards are met.

7.6 Blanching

65. Blanching is a process that involves the partial drying of raw shelled peanuts with the aim of loosening skins/testa for easy removal by blanching rollers. The blanched kernels are then sorted for discoloration manually or using electronic colour sorters. Blanching used in conjunction with gravity tables and manual or electronic sorting can remove aflatoxin-contaminated kernels by as much as 90%. If the colour sorting process is ineffective for blanched peanuts, as can occur when severe drought stress causes peanuts to dry in the soil before harvest, it is common practice to roast the blanched peanuts and perform the colour sorting process again. This accentuates the darkening process and facilitates colour sorting.

7.7 Roasting

66. Roasting can reduce total aflatoxins by 43 to 90%, depending on the process. A temperature of 200°C for 25 min can degrade about 90% of the total aflatoxins, but under this condition, some physical characteristics along with sensory properties (flavour and odour of the product) change to an undesirable burnt state. Therefore, the roasting process should be done so that the sensory characteristics, nutritional values, and overall acceptance are not impaired in the final product.

7.8 Packaging and storage of end product

67. Peanuts should be packed in appropriate packages, such as clean jute bags, cartons, or polypropylene bags. Ensure food-contact materials comply with the safety standards set by regulatory authorities. All bags/cartons should be lot-identified to facilitate traceability before being moved to controlled storage facilities or transported.

68. Peanuts that have been processed should be stored and transported under such conditions as to maintain the integrity of the container and the product within it. Carriers should be clean, dry, weatherproof, free from infestation, and sealed to prevent water, rodents, or insects from reaching the peanuts. Peanuts should be loaded, held, and unloaded in a manner that protects from damage or water. Well-insulated carriers or refrigerated vehicles are recommended for transport when climatic conditions indicate such a need. Extreme care should be taken to prevent condensation when unloading peanuts from cold storage or a refrigerated vehicle. In warm, humid weather, the peanuts should be allowed to reach room temperature before exposure to external conditions. This may require 1 to 2 days. Peanuts that have been spilled are vulnerable to contamination and should not be used for edible products.

69. Export-grade raw peanuts must be clearly labelled as either "ready-to-eat" or "destined for further processing," indicating that additional processing is required before they are used as an ingredient in foodstuffs, otherwise processed, or offered for human consumption.

7. RISK MANAGEMENT FOR AFLATOXIN CONTROL IN PEANUT CHAIN

70. The Hazard Analysis Critical Control Point (HACCP) system is an all-encompassing integrated food safety management system that is used to identify and control hazards within the production and processing system. The general principles of HACCP are described in the *General principles of food hygiene* (CXC 1-1969).

71. Aflatoxins in peanuts are both a microbial and a chemical issue. When properly implemented, this system should result in a reduction of the levels of aflatoxins in peanuts. The use of HACCP as a food safety management system has many benefits over management control systems in some segments of the food industry. Control of aflatoxin contamination during agricultural production is mainly achieved through minimizing insect infestation and controlling irrigation. Particular attention should be paid to the soil population of the fungus, the health of seed material, soil moisture deficit stress at pod formation and pod maturity stages, and rains at harvest. After harvesting, the critical control points may be identified for aflatoxins produced by fungi during drying and storage. For example, aflatoxins can be formed while peanuts are being dried, which is usually carried out in the field, and can also continue to form during farm storage if drying has been inadequate or when storage is carried out at high relative humidity and/or temperature. During manufacturing, sorting and roasting are the main steps in the reduction of aflatoxin and making them critical control points.

72. It is recommended that resources be directed to promoting Good Agricultural Practices (GAPs) and Good Manufacturing Practices (GMPs) at pre-harvest, harvest, drying, storage, processing, and distribution of various products. A HACCP system should be built on sound GAPs and GMPs.

73. Integrated aflatoxin control programs may incorporate HACCP principles to control risks associated with aflatoxin contamination of foods and feeds. Implementing HACCP principles can minimize aflatoxin contamination of peanuts through the application of preventive controls to the extent feasible in the production, handling, storage, and processing of each peanut crop.

APPENDIX II
(For information)

References in support of the revised provisions in the CoP

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