CODEX ALIMENTARIUS COMMISSION

Food and Agriculture Organization of the United Nations

World Health Organization

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Agenda Items 9 and 10 **CF/10 CRD 28 PART2**
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JOINT FAO/WHO FOOD STANDARDS PROGRAMME

CODEX COMMITTEE ON CONTAMINANTS IN FOODS

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(Submitted by Brazil)

This CRD was based on the proposed draft revision of the code of practice for the prevention and reduction of mycotoxin contamination in cereals (REP 15/CF Appendix VII) and the suggestions made by the members in CX/CF 16/10/10 and the CRDs.

PROPOSED DRAFT OF THE CODE OF PRACTICE FOR THE PREVENTION AND REDUCTION OF MYCOTOXIN CONTAMINATION IN CEREALS, INCLUDING ANNEXES ON OCHRATOXIN A, ZEARALENONE, FUMONISINS,TRICHOTHECENES AND AFLATOXINS (CAC/RCP 51-2003) (rev 2014)

INTRODUCTION

1. Toxigenic fungi are prevalent in regions in climatic zones which allow for small and large scale cereal grain production. Although the species and strains may differ among grain producing regions, these fungi are present in soils, in wild host plant species, in the residues of cultivated crops and stored grains and in the dust in drying and/or storage facilities. The fungi are associated with both pre-harvest and post-harvest mycotoxin contamination in cereals.

2. The severity of pre-harvest fungal propagation is highly dependent upon weather conditions varying greatly from year to year in grain-producing regions. The severity of pre-harvest infection and propagation of toxigenic fungi can also vary with the degree of damage caused by insects and other non-toxigenic fungi. Because of these factors, mycotoxin concentrations observed in grains at harvest vary widely from year to year. Reliable prevention of pre-harvest fungal infection has been proven to be elusive, even with application of good agricultural practices (GAP) and commercially available fungicides. Cereal breeding has resulted in only modest gains in genetic resistance to the *Fusarium* ear blight (*Fusarium* head blight) of cereals in cultivars with acceptable quality, yield and tolerance to other important cereal diseases.

3. The severity of post-harvest fungal infection and propagation during prolonged periods of grain storage can be managed more predictably through GAP and good manufacturing practices (GMP) that ensure that moisture levels in stored grain remain below levels that are conducive to germination of spores of common post-harvest fungal species specific to the environmental conditions present in the region. However, research has confirmed that spores of such species are ubiquitous in soils, equipment, and storage structures despite diligent cleaning. Consequently, germination of the spores of the mycotoxigenic species can occur within certain temperature ranges if even a small amount of stored grain develops elevated moisture levels from exposure to precipitation or insect infestation. The size and design of large grain storage structures and the limited access to technology often make precise monitoring of moisture and temperature in stored grain extremely difficult or otherwise impractical.

4. Risk of post-harvest fungal infection and production of mycotoxins in stored grain increases with the duration of storage. However, long term storage, generally throughout an entire crop year or for even longer periods, may be required depending on the grain needs of the specific production region where the commodity is being stored. This may be due to reasons of food security and the continuous input into storage of necessary cereal grains for direct consumption, processing and/or animal feed.

5. The complete prevention of dissemination by pre-harvest and post-harvest toxigenic fungal species is not practically achievable, even when GAP and GMP are followed. Therefore, the intermittent presence of certain mycotoxins in cereal grains destined for human food and animal feed use is to be expected. Thus diligent monitoring of cereal grains in the field and during storage for indications of the various conditions that

promote fungal contamination and mycotoxin accumulation is imperative to determine disposition of the commodity..

6. The General Code of Practice issued by Codex provides current and relevant information for all countries to consider in their efforts to prevent and reduce mycotoxin contamination in cereal grains, grain-derived foods and animal feeds. In order for this Code of Practice to be effective, it will be necessary for the national authorities, producers, marketers, and processors in each country to consider the general principles and examples of GAP and GMP provided in the Code, taking into account their local crops, climate, and agronomic practices to enable and facilitate adoption of these practices where relevant and feasible. This Code of Practice is expected to apply to all cereal grains and cereal products relevant to human dietary intake and health as well as international trade.

7. It is important for grain producers to realise that GAP, including post harvest, storage, handling procedures, represent the primary line of defence against contamination of cereals with mycotoxins, followed by the implementation of GMP during the handling, storage, processing and distribution of cereals for human food and animal feed. Processing industries also have a role to implement GMP where required, mainly during grain sorting, cleaning and processing.

8. Cereal grain producers should be trained to follow GAP and maintain a close relationship with agricultural advisors, extension services and national authorities to obtain information and advice regarding the choice of appropriate cereal grain cultivars and plant protection products suitable for use in their respective production regions so as to reduce incidence and levels of mycotoxins.

9. This General Code of Practice contains general principles for the reduction of various mycotoxins in cereals. For the education of producers, collectors and processors, and providing information on testing to relevant parties, the following should be observed:a) National authorities and/or other organisations should educate producers regarding the environmental factors that favor infection and growth of the toxigenic fungi, and mycotoxin production in cereal crops at the farm level. Emphasis should be placed on the fact that the planting, preharvest and postharvest strategies for a particular crop will depend on the climatic conditions of that particular region and year, taking into account the local crops, and traditional production methods for that particular country or region. National authorities should support scientific research on methods and techniques to prevent fungal growth in the field and during harvest and storage.

b) In order to avoid undue disruption of grain shipment operation, validated analytical methods and associated sampling plans should be utilized by producers/handlers/processors to quickly determine mycotoxin levels . The proper implementation of sampling plans and use of any such analytical methods or tools is critical to their provision of accurate information and data. This will require adequate resources and training to ensure that sampling plans are followed and test procedures can be properly performed. Procedures should be in place to properly handle, through segregation, reconditioning, recall or diversion, cereal crops that may pose a threat to human and/or animal health.

10. This Code for the prevention and reduction of mycotoxins in cereal grains and grain-derived foods and feeds recommends practices based on GAP and GMP and are generally consistent with Hazard Analysis Critical Control Points (HACCP) principles which are incorporated into current food safety practices and certification schemes now in global use in production, storage, handling, transportation, processing, distribution and trade. The implementation of HACCP principles will minimise mycotoxin contamination through applications of preventive control measures to the extent feasible, mainly during storage and processing of cereals.

I. RECOMMENDED PRACTICES BASED ON GOOD AGRICULTURAL PRACTICES (GAP) AND GOOD MANUFACTURING PRACTICES (GMP)

Planting and Crop Rotation

11. Consider developing and maintaining an appropriate crop rotation/sequence schedule to avoid planting the same crop in the same field, for two consecutive seasons. This can help to reduce the inoculum in the field which may originate from debris remaining after harvest that harbors toxigenic fungal spores. Some crops have been found to be particularly susceptible to certain species of toxigenic fungi and the use in rotation with each other should be evaluated. Table 1 shows the most susceptible crops to toxigenic fungi and the mycotoxins that can be produced. Some of these crops are infected after harvestand the resulting seeds can carry toxigenic fungal spores. Crops of low susceptibility to toxigenic fungi such as clover, alfalfa and other legumes can be used in rotation to reduce the inocula in the field. Wheat and maize have been found to be particularly susceptible to *Fusarium* species and they should not be used at very close positions in rotation with each other if possible. When used in the same rotation, inclusion of soybeans, oilseeds, pulses and forage crops may reduce the incidence and severity of pre-harvest infection.

Table 1. Susceptible rotation crops to toxigenic fungi associated with production of mycotoxins (not exhaustive).

Crops	Fungi	Potential of Mycotoxins
Peanuts	*Aspergillus flavus* *A. parasiticus* *A. nomius* And other related species	Aflatoxins
Maize	*A. flavus* *A. parasiticus* and other related species	Aflatoxins
	Fusarium graminearum *F. culmorum*	deoxynivalenol,nivalenol, zearalenone
	F.verticillioides *F. proliferatum*	fumonisins
Sorghum	*Fusarium graminearum* *Fusarium* spp.	deoxynivalenol,nivalenol, zearalenone and diacetoxyscirpenol
	Alternaria spp.	alternariol, alternariol methyl ether, tenuazonic acid and altenuene
	F. verticillioides *F. proliferatum*	fumonisins
	A. flavus *A. parasiticus* *A.* section *Flavi*	Aflatoxins
	P. verrucosum *A. ochraceus* and related species *A. carbonarius* *A. niger*	ochratoxin A
	Claviceps purpurea *C. Africana* *C. sorghi* and related species	ergot alkaloids
	A. versicolor	sterigmatocystin
Wheat	*Alternaria* spp.	alternariol, alternariol methyl ether, tenuazonic acid
	F. graminearum *F. culmorum* *F. asiaticum*	deoxynivalenol,nivalenol, zearalenone
Barley	*F. graminearum* *F. culmorum* *F. asiaticum*	deoxynivalenol,nivalenol, zearalenone
Oats	*F. graminearum* *F. culmorum* *F. langsethii*	deoxynivalenol,nivalenol, zearalenone, T-2 and HT-2 toxin
Rye	*F. graminearum* *Claviceps purpurea*	deoxynivalenol, ergot alkaloids
Cotton	*A. flavus* *A. parasticus*	Aflatoxins
Millet	*F. graminearum*	Deoxynivalenol
Triticale	*F. graminearum*	Deoxynivalenol

Tillage and Preparation for Seeding (Planting)

12. When possible and practical, use mycotoxin free certified seeds and prepare the seed bed for each new crop by plowing under or by destroying or removing old seed heads, stalks, and other debris that may have served, or may potentially serve as substrates for the growth of mycotoxin producing fungi. However, tilling may not be appropriate with respect to other economic and environmental benefits, such as moisture conservation, maintenance of soil organic matter, reduced erosion, and lower fuel and water use, hence its costs and benefits should be considered prior to application.
13. Utilise the results of soil tests to determine if there is a need to apply fertilizer and/or soil conditioners to assure adequate soil pH and plant nutrition to avoid plant stress, especially during seed development stage of crop growth.
14. When available, grow varieties (cultivars) that were developed and selected for their traits of providing at least partial resistance to both non-toxigenic and toxigenic fungi and insect pests and for lower mycotoxin accumulation. It is important to plant only those varieties recommended for use in a particular area of a country by virtue of their specific physiological and agronomic traits.
15. As far as practical, crop planting should be timed to avoid high temperature and drought stress during the period of seed development and maturation. Predictive models, when available, could be used as a tool to plan for the best planting period.
16. Ensure appropriate density of planting by maintaining the recommended row and intra- plant spacing for the species/varieties grown. Information concerning plant- spacing may be provided by seed companies, national authorities or extension services.

Pre-harvest

17. Where possible, minimise insect damage and fungal infection in the vicinity of the crop by proper use of approved pesticides and other appropriate practices within an integrated pest management program. Predictive weather models could be used to plan the best application timing and mode of pesticide application.
18. As certain weed species can act as hosts for toxigenic fungi that can increase plant stress due to competition of weed species during crop development, it is important to control weeds in the crop by using mechanical methods, registered herbicides or other safe and suitable weed eradication practices utilising an integrated pest management program.
19. Minimise mechanical damage to plants during cultivation, irrigation and pest management practices. Minimise lodging of plants to prevent contact of the aerial parts of the plants with soil, particularly at the flowering stage of the crop. Soil and soil water are sources of inoculum (spores) of toxigenic fungal species.
20. If irrigation is used, ensure that it is applied evenly and that all plants in the field have an adequate supply of water. Irrigation is a valuable method of reducing plant stress in some growing situations. Excess precipitation during anthesis (flowering) makes conditions favourable for dissemination and infection by *Fusarium spp*.; thus irrigation during anthesis and during the ripening of the crops, specifically wheat, barley, and rye, should be avoided.
21. Plan to harvest grain at low moisture content and full maturity, unless allowing the crop to continue to full maturity would subject it to extreme heat, rainfall or drought conditions. Delayed harvest of grain already infected by *Fusarium* species may cause an increase in the mycotoxin content of the crop. Models could be used to predict the mycotoxin production based on environmental conditions, such as climate conditions and agricultural production conditions, being a guide to timely monitoring and surveying of mycotoxin levels.
21 bis. If mechanical drying equipment is available, earlier harvest may be helpful in limiting mycotoxin production during the final stages of crop maturation. It is important to use proper drying techniques in order to avoid contamination by contaminants generated by improper drying techniques such as polycyclic aromatic hydrocarbons (PAH) and dioxins.
22. Before harvest ensure that all equipment, to be used for harvesting, drying, cleaning and storage of crops, is in a good working order and cleaned of crop residues, grain and dust as much as possible. A breakdown of equipment during this critical period may cause grain quality losses and enhance mycotoxin formation. Keep important spare parts available on the farm to minimise time loss from repairs. Make sure that the equipment needed for moisture content measurements is available and calibrated.

Harvest

23. Containers and conveyances (e.g. wagons, trucks) to be used for collecting and transporting the harvested grain from the field to drying facilities, and to storage facilities after drying, should be clean, dry and free of crop residues, old grain, grain dust, insects and visible fungal growth before use and re-use.
24. Methods of harvest and equipment used vary widely among grain-producing countries. Cutting of grain into swaths prior to combining or threshing by other means can contribute to contact with the soil and exposure to fungal spores. As far as possible, avoid mechanical damage to the grain and avoid contact with soil during the harvesting operation. Steps should be taken to minimise the spread of infected seed heads,

chaff, stalks, and debris (crop residues) onto the ground where spores and other fungal structures may survive and serve as inocula for future crops. Mechanised harvest methods such as the use of combines result in large amounts of the crop residue being left in the field. Where crop rotation/ sequence and related tillage practices permit, it is preferable to incorporate this crop residue into the soil by ploughing or cultivation by other means.

25. During harvesting operation, the moisture content should be determined in several spots of each load of the harvested grain since the moisture content may vary considerably within the same field. As far as possible, avoid harvesting grain with high moisture content due to precipitation or morning dew or during late afternoon as it takes a longer time to dry. If possible, when preharvest monitoring or surveying of grain shows a field as having a higher *Fusarium* infection rate, harvest and store grain from such field(s) separately from those fields with a lower infection rate.

26. Harvested grain that has not been dried to a safe storage moisture level should not be stored or transported in bins, wagons or trucks for prolonged periods of time. Transit time for movement from field to drying facility should be minimised unless the grain is already at acceptable storage moisture levels before harvest. When necessary it is recommended that the trucks and containers be opened, to increase aeration and minimise the condensation effects.

Drying and cleaning before storage

27. Avoid piling, heaping, or bin storage of high-moisture, freshly harvested commodities for more than a few hours prior to drying or threshing to lessen the risk of fungal growth. If it is not possible to dry the commodities immediately, aerate them by forced air circulation.

28. When necessary pre-cleaning before drying can be carried out to remove large amounts of straw or other plant material that can carry mold or mold spores. Winnowing and sorting methods can be utilised to clean the grain. If cleaning equipment is available, it is advantageous to mechanically clean grain to remove foreign material, seeds of other plant species, and crop residues prior to transfer to storage structures. However it is important that the grain is not damaged during the procedure.

29. It is very important to ensure that moisture levels in harvested grains are low enough to permit safe storage for even relatively short periods of time ranging from a few days to a few months. A maximum level of 15% moisture is generally considered to be low enough to prevent further growth of pre-harvest toxigenic fungi and germination of spores of fungi that typically infect grain and produce mycotoxins during storage, such as *Penicillium.*

30. Freshly harvested cereals should be dried immediately in such a manner that damage to the grain is minimised and moisture levels are lower than those needed for fungal growth during storage. It is preferable to reduce grain moisture content to an acceptable level prior to transfer to storage bins and other storage structures. If it is not possible to dry the commodities immediately, aerate them by forced air circulation and keep the period before drying as short as possible. Mechanical drying is preferred. Flat bed and re-circulating batch driers are adequate for small scale operations while using a continuous flow-dryer is preferred for large scale drying prior to long storage periods. Grains should not be excessively dried or subjected to excessively high drying temperatures in order to preserve nutritional quality and suitability for milling or other processing. The use of good drying practices is essential to avoid contaminants generated by the process. Avoid accumulating too much grain in the pre-drier storage or "wet tank", especially when field conditions are warm. Store grains only enough that can be easily dried in a suitable time period.

31. If mechanical means of drying are not available, sun and open air drying should be done on clean surfaces; to the extent possible, grains should be protected from rain, dew, soil, pests, bird droppings and other sources of contamination during this process. For more even and faster drying, mix or stir grains frequently in thin layers to dry evenly and quickly.

32. After drying, cereal grain should be cleaned to remove damaged and immature kernels and other foreign matter. Kernels containing symptomless infections cannot be removed by standard cleaning methods. Seed cleaning procedures, such as gravity tables and optical sorting, may remove broken kernels that are susceptible to infection.

Storage after drying and cleaning

33. It is important that bins, silos, sheds and other buildings intended for grain storage are dry, well-vented structures that provide protection from rain, snow, ground water, moisture condensation, and the entry of rodents, birds and insects that can not only contaminate grain but damage grain kernels to render them more susceptible to mold infection. Ideally, storage structures should be designed so as to minimise wide fluctuations in the temperature of the stored grain.

34. Storage facilities should be cleaned prior to receiving grain to remove dust, fungal spores, grain, crop residues, animal and insect excreta, soil, insects, foreign material such as stones, metal and broken glass, and other source of contamination.

35. For bagged commodities, ensure that bags are clean, dry and stacked on pallets or incorporate a water impermeable layer between the bags and the floor. The bags should facilitate aeration and be made of non-toxic food-grade materials, that do not attract insects or rodents and are sufficiently strong to resist storage for longer periods.

36. Determine moisture content of the lot, and if necessary, dry the crop to the moisture content recommended for storage. Fungal growth in grain is closely related with water activity (a_w), commonly defined in foods as the water that is not bound to food molecules (such as milled grain products) that can support the growth of bacteria, yeasts, and fungi. Although the appropriate moisture content for fungal growth on various grains is different, the maximum a_w to avoid fungal growth is basically the same. It is recognized that fungal growth is inhibited at a_w of less than 0.70 . In general, the moisture content of grains during storage should not be higher than 15%. Appropriate level of moisture content of grain should be determined based on cereal variety, kernel size, grain quality, storage period and storage condition (e.g. temperature). In addition, safe storage guidance may be provided to reflect the environmental situation in each region. Table 2 shows values of moisture content in relation to different water activities at 25ºC for some cereals.

Table 2. Values of grain moisture content in relation to water activities at 25ºC for some cereals.

Cereal	**Moisture content (%) at various water activities**			
	0.60	**0.65**	**0.70**	**0.75**
Rice	13.2	13.8	14.2	15.0
Oat	11.2	12.2	13.0	14.0
Rye	12.2	12.8	13.6	14.6
Barley	12.2	13.0	14.0	15.0
Maize	12.8	13.4	14.2	15.2
Sorghum	12.0	13.0	13.8	14.8
Wheat	13.0	13.6	14.6	15.8

37. Ongoing monitoring of the condition of stored grain is essential to ensure the grain is kept at acceptable temperature and moisture levels and substantially free of rodents and stored product pests such as grain beetles, weevils and mites. Significant fluctuations in grain temperature and increases in grain moisture can provide favourable conditions for mold growth and production of mycotoxins. Physical damage to grain kernels during storage caused by rodents and pests, such as insects and mites, can also contribute to increases in mold growth. The mycotoxin level in in-bound and out-bound grain should also be measured when relevant, using adequate sampling and testing programs that are appropriate to the mycotoxin monitoring system.

38. To more effectively monitor the condition of stored grain, it is advisable, if possible, to measure the temperature and humidity of the storage facilities and the stored grain at regular time intervals during storage. A grain temperature rise of 2-3°C may indicate microbial growth and/or insect infestation. If temperature or moisture becomes unacceptably high, where possible, aerate the grain by circulation of air through the storage area to maintain proper and uniform temperature levels. Aeration should be conducted, if possible, during periods of low ambient relative humidity of air being forced through the mass of stored grain. Aeration during periods of high relative humidity can actually increase condensation and a_w in stored grain whose temperature is below ambient air temperature. Grain can also be transferred from one storage container to another to promote aeration and disruption of potential hot spots during storage. If grain spoilage or mold growth in grain is observed, separate the apparently infected portions of the grain and collect samples for mycotoxins analyses, using appropriate sampling plans. When spoiled grain is removed, it is extremely important to minimise the mixing of the spoiled grain with the remaining portion of grain that appears to be in good condition. Small quantities of highly contaminated grain can greatly increase mycotoxin levels in grain that is otherwise in good condition. After spoiled grain has been removed, it may be necessary to aerate the remaining grain to lower the temperature and the moisture to acceptable levels.

39. For cold climate countries, it is important to note that reduction of grain temperature below 15º C that can occur during colder months of temperate grain producing regions will contribute to safe storage and prevention of mould growth and mycotoxin production. Extremely cold temperatures will also inhibit insect growth and reproduction, reducing the risk of insect damage which can facilitate mould growth.

40. Use good housekeeping procedures to minimise the levels of rodent pests, insects and fungi in storage facilities. This may include the use of suitable, registered insecticides and fungicides or appropriate alternative methods within an integrated pest management program. Care should be taken to select and use only those pest control products that will not create a safety concern based on the intended end use of the grains and the maximum levels of pesticide residue dictated by regulation or buyer specifications. Since rodent pests can damage the crop during storage, the storage facility must be kept free of rodents such as rats and mice to the extent possible.

41. The use of a suitable, approved preservative (e.g. organic acids such as propionic acid) may be beneficial. These acids are effective in killing various fungi and thus prevent the production of mycotoxins in grains intended only for animal feed. The salts of the acids are usually more effective for long-term storage. Care must be taken because these compounds can negatively affect the taste and odour of the grain.

42. Document the harvesting, drying, cleaning and storage procedures implemented each season by making notes of measurements (e.g. temperature, moisture, and humidity) and any deviation or changes from traditional practices. This information may be very useful for explaining the cause(s) of fungal growth and mycotoxin formation during a particular crop year and help to avoid similar occurrences in the future. Management measures taken by making use of validated predictive models, when available, could be used to control fungal growth and mycotoxin production during these procedures.

Transport from storage

43. Transport containers, vehicles such as trucks and railway cars and vessels (boats and ships) should be dry and free of old grain, grain dust, visible fungal growth, musty odour, insects and any contaminated material that could contribute to mycotoxin levels in lots and cargoes of grain. As necessary, transport containers should be cleaned and disinfected with appropriate substances (which should not cause off-odours, flavour or contaminate the grain) before use and re-use and be suitable for the intended cargo. The use of registered fumigants or insecticides may be useful. At unloading, the transport container should be emptied of all cargo and cleaned as appropriate.

44. Shipments of grain should be protected from additional moisture by using covered or airtight containers or tarpaulins. Minimise temperature fluctuations and measures that may cause condensation to form on the grain, which could lead to local moisture build-up and consequent fungal growth and mycotoxin formation.

45. Avoid insect, bird and rodent infestation during transport by the use of insect-and rodent proof containers or insect and rodent repellent chemical treatments if they are approved for the intended end use of the grain.

Processing and cleaning after storage

46. Sorting and cleaning are effective processes to remove contaminated grains and reduce mycotoxin content in cereals. Visibly moldy infected and/or damaged kernels should be discarded in order to prevent their entry into the food and livestock feed supply chains. This is particularly important if the grain is intended for direct human consumption rather than industrial processing.

47. Analytical testing can be used as a tool to monitor mycotoxin concentrations throughout the cereal grain supply chain. It is important that sampling plans and analytical testing are properly implemented in order to provide accurate and representative results. In some cases, simple screening tests are commercially available for certain mycotoxins, such as DON; however, the proper implementation of sampling plans and use of any such tests or tools is critical to their provision of accurate information and data. This will require commitment of adequate resources and training so that sampling plans and test procedures can be properly performed. It is important that the cereal grains removed from storage for transport are tested at loading or unloading for mycotoxin concentrations before going into storage at grain processing facilities, especially when the risk of mycotoxin contamination is high as a consequence of unfavourable conditions during grain production and harvest. Lots containing higher levels of mycotoxin should undergo extensive cleaning and processing that significantly decreases mycotoxin to acceptable levels in order to guarantee a safe product to consumers.

48. Brushing, scouring and peeling to remove hulls and bran layers of the grain can significantly reduce mycotoxin content in milling fractions derived from the endosperm (i.e. flour) as the outer parts of the kernel of most cereal grains typically contains higher mycotoxin levels or adhering contaminated dust. Such redistribution of the mycotoxins present in unprocessed grains can result in unacceptably high levels of mycotoxins in other fractions (e.g. bran) and products that contain such fractions. Where these fractions are to be used for food use rather than being discarded, it is also important to monitor mycotoxin levels to ensure food safety in the products as consumed. Caution and proper procedures should be followed when using such removed fractions as animal feed.

49. Industrial dry milling of grain to produce whole grain products containing all portions of the unprocessed kernels in their naturally occurring relative proportions will not reduce mycotoxin levels from those observed in the unprocessed grain. Dry milling processes that segregate some or all of the hull and bran layers of the grain can significantly reduce the mycotoxin content of milled products derived from grain endosperm (inner portions of kernels) used as food ingredients to levels below those present in the unprocessed grain. Wet milling of maize grain isolates most mycotoxins from the starch fraction used as food ingredients.

50. Milled grain products that are stored for long periods of time are also susceptible to mold growth and increased mycotoxin levels imparted by the mold species Therefore, it is important to avoid storing flour and

other milled grain products for long periods of time, but if it is unavoidable, then the products should be stored in proper storage containers and safe moisture levels should be maintained with minimum temperatures changes. Such containers must deter insect and rodent infestation and should be subject to integrated pest control measures.

51. For grain products and grain-derived foods that pass through a fermentation step, poorly preserved starter cultures can be significant sources of mycotoxin contamination. The starter cultures should be maintained pure, viable and sealed to prevent water access and other contamination.

52. The beer steeping process (soaking and germination phases) raises the seed moisture level to about 45% which is favourable for fungal growth and mycotoxin production. The situation is problematic if the process is done under open, poor sanitary conditions. Therefore, steeping should be carried out in weatherproof containers under controlled atmosphere.

53. All grain processing activities should follow good hygiene practices and HACCP-based GMP.

This CRD was based on CX 10/11and the suggestions made by the members in CX/CF 16/10/11 Add. 1 and the CRDs.

PROPOSED DRAFT ANNEXES TO THE CODE OF PRACTICE FOR THE PREVENTION AND REDUCTION OF MYCOTOXIN CONTAMINATION IN CEREALS (CAC/RCP 51-2003)

ANNEX 1

PREVENTION AND REDUCTION OF CONTAMINATION BY ZEARALENONE IN CEREAL GRAINSRECOMMENDED PRACTICES BASED ON GOOD AGRICULTURAL PRACTICES (GAP) AND GOOD MANUFACTURING PRACTICES (GMP)

1. Good Agricultural Practices and Good Manufacturing Practices include methods to reduce *Fusarium*infection (mainly *F. graminearum* and *F. culmorum*) and zearalenone(ZEN) production in cereals during the crop growth and development, harvest, storage, transport and processing. However, ZEN occurs primarily due to pre-harvest infection of maize, wheat and barley with the relevant *Fusarium* spp.

Planting

2. Refer to paragraphs 11-16 in the General Code of Practice for the Prevention and Reduction of Mycotoxin Contamination in Cereals.

Pre-harvest

3. Refer to paragraphs 17-22 in the General Code of Practice.

4. The establishment of toxigenic *Fusarium* infection in cereal heads during flowering may need to be monitored before harvest by inspection, sampling and determination of infection by standard microbiological methods. Also, mycotoxin content in representative pre-harvest samples may need to be determined. Utilisation of the crop should be based on prevalence of infection and mycotoxin content of the grain.

5. ZEN risk in wheat increases with pre-harvest rainfall especially if harvest is then delayed. Predictive modelling for risk of *Fusarium* infection may be useful to plan to harvest grain before wet weather conditions prevailIn parallel with predictive modeling for risk of *Fusarium* infection weather forecast may be used for planning the harvest.

Harvest

6. Refer to paragraphs 23-26 in the General Code of Practice.

Drying and cleaning

7. Refer to paragraphs 27-32in the General Code of Practice.

Storage after Drying and Cleaning

8. Refer to paragraphs 33-42 in the General Code of Practice.

Transport from storage

9. Refer to paragraphs 43-45 in the General Code of Practice.

Processing

10. Refer to paragraphs 46-53 in the General Code of Practice.

11. Wet milling of wheat and maize can result in significant reduction of ZEN levels in starch fractions intended for food use. However, the ZEN is in effect redistributed to the by-products of starch, gluten and sweetener production that are typically used for animal feed.

ANNEX 2

PREVENTION AND REDUCTION OF CONTAMINATION BY FUMONISINS IN CEREAL GRAINS

RECOMMENDED PRACTICES BASED ON GOOD AGRICULTURAL PRACTICES (GAP) AND GOOD MANUFACTURING PRACTICES (GMP)

1. Good Agricultural Practices and Good Manufacturing Practices include methods to reduce *Fusarium* infection (mainly *F. verticillioides* and *F. proliferatum*) and fumonisin contamination of cereals during the crop growth and development, harvest, storage, transport and processing.

Planting

2. Refer to paragraphs 11-16 in the General Code of Practice.

Pre-harvest

3. Refer to paragraphs 17-22in the General Code of Practice.

Harvest

4. Refer to paragraphs 23-26 in the General Code of Practice.

5. The time of harvest for maize should be carefully planned. It has been shown that maize grown and harvested during warm months may have fumonisin levels significantly higher than maize grown and harvested during cooler months of the year. Predictive models developed for the risk of *Fusarium* infection may be used for planning the best harvest time.

Drying and Cleaning

6. Refer to paragraphs 27-32 in the General Code of Practice.

Storage after Drying and Cleaning

7. Refer to paragraphs 33-42 in the General Code of Practice.

Transport from storage

8. Refer to paragraphs 43-45 in the General Code of Practice.

Processing

9. Refer to paragraphs 46-53 in the General Code of Practice.

10. Nixtamalization is a process that involves boiling and soaking maize in a solution of calcium hydroxide to remove the hull. This process may reduce fumonisin levels in the treated maize as well as in the masa flour used in making corn tortillas, tamales, pupusas and other masa derived products.

11. Extrusion of maize may decrease fumonisin levels, however part of it is bound to proteins, sugars or other compounds in food matrices.

ANNEX 3

PREVENTION AND REDUCTION OF CONTAMINATION BY OCHRATOXIN A IN CEREAL GRAINS

RECOMMENDED PRACTICES BASED ON GOOD AGRICULTURAL PRACTICES (GAP) AND GOOD MANUFACTURING PRACTICES (GMP)

1. Good Agricultural Practices and Good Manufacturing Practices include methods to reduce *Aspergillus* (mainly *A. ochraceus* and related species, *A. carbona*rius and *A. niger*) and *Penicillium* (mainly *P. verrucosum*) infection and ochratoxin A (OTA) contamination of cereals during crop growth and development, harvest, storage, transport and processing.

Planting

2. Refer to paragraphs 11-16 in the General Code of Practice.

3. Do not grow cereals close to cocoa trees, coffee bean plants or grape vines as these crops are highly susceptible to ochratoxigenic fungi and OTA contamination and can represent a source of inoculum tothe soil.

Pre-harvest

4. Refer to paragraphs 17-22 in the General Code of Practice.

5. Although OTA is associated with post-harvest fungal growth in stored grains, frost damage, presence of competitive fungi, excessive rainfall and drought stress arepre-harvest factors that may affect levels of OTA in harvested grains. Crop lodging on the field can also result in the production of OTA in humid conditions.

Harvest

6. Refer to paragraphs 23-26 in the General Code of Practice.

Drying and cleaning

7. Refer to paragraphs 27-32 in the General Code of Practice.

8. OTA is produced in cereals due to poor drying or storage conditions. Grain should be allowed to dry as much as possible before harvest consistent with local environment and crop conditions. If it is necessary to harvest the grain before its water activity becomes lower than 0.70, dry the grain to a moisture content corresponding to a water activity of less than 0.70 (preferably 0.65). In a temperate climate region, when intermediate or buffer storage is necessary because of low drying capacity, make sure that the moisture content is lower than 15%, the buffer storage time is less than 10 days, and the grain temperature is lower than 20°C, in general. Appropriate conditions for intermediate or buffer storage may be determined on the basis of cereal variety, kernel size, grain quality and outside air temperature.

Storage after Drying and Cleaning

9. Refer to paragraphs 33-42 in the General Code of Practice.

Transport from storage

10. Refer to paragraphs 43-45 in the General Code of Practice.

Processing

11. OTA is highly stable and does not degrade in primary processing (e.g. milling into flour) or further processing (e.g. baking into bread). Its distribution in unprocessed grain is heterogeneous, as the toxin is typically present in high concentrations in a very small number of grain kernels (“hot spots”). As grain is processed, the OTA is redistributed among milled grain fractions, yielding lower levels in endosperm flour fractions and higher levels in bran fractions relative to those found in the unprocessed grain.

12. Refer to paragraphs 46-53 in the General Code of Practice.

ANNEX 4

PREVENTION AND REDUCTION OF CONTAMINATION BY TRICHOTHECENES IN CEREAL GRAINS

RECOMMENDED PRACTICES BASED ON GOOD AGRICULTURAL PRACTICES (GAP) AND GOOD MANUFACTURING PRACTICES (GMP)

Good Agricultural Practices and Good Manufacturing Practices include methods to reduce trichothecenes producing *Fusarium spp* infection and trichothecene contamination of cereals during crop growth and development, harvest, storage, transport and processing. The more common trichothecenes are deoxynivalenol (DON produced mainly by *F.graminearum* and *F.culmorum*), T-2 toxin, HT-2 toxin (produced mainly by *F.sporotrichioides* and *F. poae*), , diacetoxyscirpenol (DAS produced by *F.equisiti, F. poae, F. acuminatum*) and nivalenol (NIV produced by *F.nivale, F.poae,F.culmorum* and *F.graminearum*)

Planting

2. Refer to paragraphs 11-16 in the General Code of Practice.

Pre-harvest

3. Refer to paragraphs 17-22 in the General Code of Practice.

4. Use predictive models developed for risk of *Fusarium* infection of wheat and other small grains, which may assist producers in decisions on the necessity and timing of fungicide application. The establishment of *Fusarium* infection in cereal heads during flowering may need to be monitored before harvest by sampling and determination of infection by standard microbiological methods. Also, mycotoxin content in representative pre-harvest samples may need to be determined. Utilisation of the crop as food or animal feed should be based on prevalence of infection and mycotoxin content of the grain.

Harvest

5. Refer to paragraphs 23-26 in the General Code of Practice.

6. Do not permit mature grains to remain in the field for extended periods of time, particularly in cold, wet weather to avoidT-2 and HT-2 toxins formation.

Drying and Cleaning

7. Refer to paragraphs 27-32 in the General Code of Practice.

Storage after Drying and Cleaning

8. Refer to paragraphs 33-42 in the General Code of Practice.

Transport from storage

9. Refer to paragraphs 43-45 in the General Code of Practice.

Processing

10. Refer to paragraphs 46-53 in the General Code of Practice.

11. Extrusion of cereal may reduce trichothecene levels in processed products, especially of DON.

12. Separated hulls and seed coat (bran layers) fractions from processed grains to be used in foods may contain unacceptably high levels of DON and must be examined for DON levels before they are processed into consumable products.

ANNEX 5

PREVENTION AND REDUCTION OF CONTAMINATION BY AFLATOXINS IN CEREAL GRAINS

RECOMMENDED PRACTICES BASED ON GOOD AGRICULTURAL PRACTICES (GAP) AND GOOD MANUFACTURING PRACTICES (GMP)

1. Good Agricultural Practices and Good Manufacturing Practices include methods to reduce *Aspergillus* infection (mainly *A. flavus, A. parasiticus* and *A. nomius*) and aflatoxin production in cereals during the crop growth and development, harvest, storage, transport and processing.

Planting

2. Refer to paragraphs 11-16 in the General Code of Practice.

3. If available and cost effective, extension officers should assist the farmers in procuring and releasing non aflatoxigenic *A. flavus* and *A. parasiticus* into the agricultural environment to suppress the natural occurrence of the aflatoxigenic fungi following the instructions of the manufacturer.**Pre-harvest**

4. Refer to paragraphs 17-22 in the General Code of Practice.

5. Biological methods can be used for the control of aflatoxins, but the applied product must be approved by relevant authorities, safe, and cost-effective towards the targeted toxin producing fungi.

Harvest

6. Refer to paragraphs 23-26 in the General Code of Practice.

Drying and Cleaning

7. Refer to paragraphs 27-32 in the General Code of Practice.

8. Aflatoxins occur in maize before harvest due to growth of toxigenic fungi as the result of insect infestation, bird and other animal damage, drought stress, hail damage or a combination of these factors. Aflatoxins rarely occur in small grains, except in sorghum and as the result of poor storage practices. Grain should be allowed to be as dry as possible before harvest in a way consistent with the local environmental and crop conditions. If it is necessary to harvest the grain before water activity becomes lower than 0.70, the grain is to be dried to a moisture content corresponding to a water activity of less than 0.70 (preferably 0.65)immediately after the harvest and as soon as possible. In temperate climate region, when intermediate or buffer storage is necessary because of low drying capacity, ensure that the moisture content is less than 15%, the buffer storage time is less than 10 days, and the grain temperature is lower than 20°C, in general. Appropriate conditions for intermediate or buffer storage may be determined on the basis of cereal variety, kernel size, grain quality and outside air temperature.**Storage after drying and cleaning**

9. Refer to paragraphs 33-42 in the General Code of Practice.

10. The formation of aflatoxins in cereals should be prevented during storage by minimizing the time between harvest and appropriate drying for storage and transport and maintaining the moisture content at a safe level (<0.70).**Transport from storage**

11. Refer to paragraphs 43-45 in the General Code of Practice.

Processing

12. Refer to paragraphs 46-53 in the General Code of Practice.

13. Nixtamalization is a process that involves boiling and soaking maize in a solution of calcium hydroxide to remove the hull. This process may reduce aflatoxin levels in the treated maize as well as in the masa flour used in making corn tortillas, tamales, pupusas and other masa derived products.