CODEX ALIMENTARIUS COMMISSION E

Food and Agriculture Organization of the United Nations

World Health Organization

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Agenda Item 11 **CX/CF 15/9/10**

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CODEX COMMITTEE ON CONTAMINANTS IN FOODS

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

(Prepared by the Electronic Working Group led by Brazil and co-chaired by Nigeria and the United States of America)

Codex Members and Observers wishing to submit comments at Step 3 on the proposed draft Code of Practice for the Prevention and Reduction of Mycotoxin Contamination in Cereals (general provisions and specific annexes), including possible implications for their economic interests, should do so in conformity with the *Uniform Procedure for the Elaboration of Codex Standards and Related Texts* (Codex Alimentarius Commission Procedural Manual) before **31 January 2015**. Comments should be directed:	
to: Mrs Tanja Åkesson Codex Contact Point Ministry of Economic Affairs P.O. Box 20401 2500 EK The Hague The Netherlands E-mail: info@codexalimentarius.nl	with a copy to: Secretariat, Codex Alimentarius Commission, Joint FAO/WHO Food Standards Programme, Viale delle Terme di Caracalla, 00153 Rome, Italy E-mail: codex@fao.org

BACKGROUND

1. The 8th Session of the Committee on Contaminants in Foods (2014) agreed that new work on the revision of the *Code of Practice for the Prevention and Reduction of Mycotoxin Contamination in Cereals* (CAC/RCP 51-2003) was timely in view of the newer technologies and practices available to prevent and reduce mycotoxin contamination in cereals. The Committee agreed to establish an electronic working group lead by Brazil and co-chaired by United States of America and Nigeria to prepare a proposed draft revise COP, including the integration of the annex on the prevention and reduction of aflatoxins and OTA in sorghum.[1]

2. The eWG revised the COP as recommended by CCCF. The list of participants is included.

3. A proposal was made to include an Annex for ergot alkaloids but was not unanimously supported by the members of the eWG. The Committee should decide on the inclusion of this Annex or whether the matter should be discussed separately by means of a discussion paper to provide scientific justification to substantiate the provisions in the proposed Annex and their inclusion in the COP.

REQUEST FOR COMMENTS

4. Codex members and international observer organizations are invited to submit comments on the provisions in the COP in particular those new provisions arising from the revision of the current COP[2]. In addition, comments are invited on the proposals to include an Annex for ergot alkaloids.

[1] REP14/CF, paras 97-99, Appendix IX

[2] The Code of Practice for the Prevention and Reduction of Mycotoxins Contamination in Cereals (CAC/RCP 51-2003) is available for consultation on the Codex website at: http://www.codexalimentarius.org/ ("Standards" or "Committee and Task Forces", CCCF, Related Standards).

PROPOSED DRAFT REVISION 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 [ERGOT ALKALOIDS]

(CAC/RCP 51-2003)

Introduction

1. Mycotoxigenic 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. Because of this, mycotoxin concentrations observed in grains at harvest vary widely from year to year. Reliable prevention of pre-harvest fungal infection has 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 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 availability of technology often make precise monitoring of moisture and temperature impractical.

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

5. The complete prevention of dissemination by pre-harvest and post-harvest mycotoxigenic fungal species is not practically achievable, even when GAP and GMP are followed. Therefore, the intermittent and presence of mycotoxins in cereal grains destined for food and animal feed use is to be expected.

6. The elaboration of a General Code of Practice by Codex will provide current and relevant information for all countries to consider in their efforts to control 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 applies to all cereal grains and cereal products relevant for human health and international trade.

7. It is important for grain producers to realize that GAP, including storage and handling methods, represent the primary line of defense 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. Industry has the role to implement GMP where required, mainly during 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 cultivars and plant protection products suitable for use in their respective production regions.

9. This General Code of Practice contains general principles for the reduction of various mycotoxins in cereals. For the education of producers and providing information on testing to relevant parties, the following should be observed:

(a) National authorities and/or other organizations should educate producers regarding the environmental factors that cause infection and growth of the mycotoxigenic 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) b)There is a need to make this Code available for producers/handlers/processors to access quick, affordable and accurate test kits and associated sampling plans that will allow testing of grain shipments without undue disruption of operations; proper use and implementation of any such test kits or tools is critical to their provision of accurate information and data. 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 minimize mycotoxin contamination through applications of preventive control measures to the extent feasible mainly during storage and processing of cereals.

Planting

11. Consider developing and maintaining a crop rotation schedule appropriate to the region to avoid planting the same crop in the same field, for two consecutive seasons in order to reduce the inoculum in the field. Some crops have been found to be particularly susceptible to certain species of mycotoxigenic fungi and the use in rotation with each other should be evaluated. Table 1 shows the most susceptible crops to mycotoxigenic fungi and the mycotoxins that can be produced. Some of these crops are infected after harvest, but the seeds can carry mycotoxigenic fungal spores. Crops of low susceptibility to mycotoxigenic fungi such as clover, alfalfa, beans and other legumes can be used in rotation to reduce the inoculums 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, oilseed and pulse may reduce the incidence and severity of pre-harvest infection.

Table 1. Susceptible rotation crops to mycotoxigenic fungi associated with production of mycotoxins.

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

Crops	Fungi	Potential of Mycotoxins
Sorghum	*Fusarium graminearum*	deoxynivalenol, nivalenol, zearalenone
	Alternaria spp.	alternariol, methyl ether alternariol, tenuazonic acid
	F.verticillioides, *F. proliferatum*	fumonisins
	A. flavus *A. parasiticus*and related species	aflatoxins
Wheat	*Alternaria* spp.	alternariol, methyl ether alternariol, 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*	deoxynivalenol, nivalenol, zearalenone
Rye	*F. graminearum* *Claviceps purpurea*	deoxynivalenol, ergot alkaloids
Cotton	*A. flavus* *A. parasticus*	aflatoxins
Milet	*F. graminearum*	deoxynivalenol
Triticale	*F. graminearum*	deoxynivalenol,

Ref: Miller (1995); Pitt (2006); Pitt & Hocking (2009); Chulze SN et al (1996), Farnochi MC, Pascale M et al (1996). De la Campa et al (2005); Miller (1995); Pitt (2006); Pitt & Hocking (2009); Scott (2009)

Tillage and Preparation for Seeding (Planting)

12. When possible and practical, 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. Utilize the results of soil tests to determine if there is 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 grain varieties (cultivars) developed for resistance to toxigenic fungi and insect pests and for lower mycotoxin accumulation. Seed only those varieties recommended for use in a particular area of a country.

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.

Preharvest

17. Where possible, minimize insect damage and fungal infection in the vicinity of the crop by proper use of registered insecticides, fungicides and other appropriate practices within an integrated pest management program. Predictive models could be used to plan the best application time for pesticide application.

18. Control weeds in the crop by using mechanical methods, registered herbicides or other safe and suitable weed eradication practices utilizing an integrated pest management program.

19. Minimize mechanical damage to plants during cultivation, irrigation and pest management practices. Minimize lodging of plants to prevent contact of the ear with soil.

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 favorable 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 a significant 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.

22. Before harvest, ensure that all equipment, to be used for harvesting, drying, cleaning and storage of crops, is in 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 minimize 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. As far as possible, avoid mechanical damage to the grain and avoid contact with soil during the harvesting operation. Steps should be taken to minimize the spread of infected seed heads, chaff, stalks, and debris onto the ground where spores may inoculate future crops.

25. During the 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 contents due to precipitation or morning dew and late afternoon as it takes a longer time to dry. If possible, harvest grain in such field(s) as shown to have a higher infection rate by *Fusarium* ear blight through preharvest monitoring or surveying of grain from fields with a lower infection rate.

26. In transport in closed containers or trucks should avoid grains with high moisture content remain long period these conditions before drying. When necessary it is recommended that the trucks and containers to be opened, to increase aeration and minimize the condensation effects.

Drying and Cleaning

27. Avoid piling or heaping 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. Sorting and washing methods can be utilized to clean the grain. However it is important that the grain not be damaged during the procedure and that it is dried thoroughly if washing is used.

29. Freshly harvested cereals should be dried immediately in such a manner that damage to the grain is minimized and moisture levels are lower than those needed for fungal growth during storage. 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.

30. Sun drying should be done on clean surfaces; grains should be protected from rain and dew during this process. For even and faster drying, mix or stir grains frequently in thin layers to dry evenly and quickly. Drying could also be done using mechanical dryers. Flat bed and re-circulating batch driers are adequate for small scale operations while using a continuous flow-dryer will suffice for large scale drying for long storage periods. Grains should not be over dried to avoid deterioration of the quality including grain damage.

Storage after drying and cleaning

31. Determine moisture content of the lot, and if necessary, dry the crop to the moisture content recommended for storage. The fungal growth in grain is closely related with water activity (a_w). Although the appropriate moisture content for fungal growth on various grains is different, the aw is basically the same. Researchers have shown that recommended a_w to avoid fungal growth is generally 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 moisture content in relation to water activities at 25ºC for some cereals.

Cereal	**Water activity at 25ºC**			
	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

Ref: Cal-Vidal (1982)

32. An integrated pest management program should also be applied during storage.

33. Make sure that the storage facilities include dry, well-vented structures that provide protection from rain, drainage of ground water, protection from entry of rodents, birds and insects and minimize the impact of temperature fluctuations. When possible, the storage structure may have dust collection system.

34. The storage facility should be frequently cleaned to remove dust, fungal spores, rest of grains, soil, insects and other source of contamination.

35. Start with high quality and mature grains where possible, which are free from mechanical, insect or mold damage. Crops to be stored should be dried to safe moisture levels where required and cooled as quickly as possible after harvest. Minimize the amount of foreign materials, immature kernels and damaged kernels in stored grains.

36. The mycotoxin level in in-bound and out-bound grain should be monitored when warranted, using sampling and testing programs that are appropriate to the mycotoxins of interest.

37. 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 materials, preferably food grade hydrocarbon-free bags that do not attract insects and rodents and are sufficiently strong to resist storage for longer periods. When stored by the conventional system bagged grains should enter storage with moisture content less than 1% of the reference moisture held by the bulk storage system.

38. Where possible, aerate the grain by circulation of air through the storage area to maintain proper and uniform temperature levels. Grain can also be transferred from one storage container to another to promote aeration and disruption of potential hot spots during storage. Check moisture content and temperature in the stored grain at regular intervals during the storage period. A grain temperature rise of 2-3°C may indicate microbial growth and/or insect infestation. Separate the apparently infected portions of the grain and send samples for analysis. When separated, lower the temperature of the remaining grain and aerate. Avoid using moldy grain for food or feed production.

39. Measure the temperature and humidity of the storage facilities at several fixed time intervals during storage.

40. Use good housekeeping procedures to minimize 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 only those chemicals that will not create a safety concern based on the intended end use of the grains and should be strictly limited. Since rodent pests can damage the crop during storage, the storage facility must be made rodent proof.

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 odor 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 mistakes in the future. Validated predictive models, when available, could be used to control fungal growth and mycotoxin production during these procedures.

Transport from storage

43. Transport containers should be dry and free of old grain, grain dust, visible fungal growth, insects and any contaminated material. As necessary, transport containers should be cleaned and disinfected with appropriate substances (which should not cause off-odors, flavor 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. Minimize 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

46. Sorting and cleaning are effective processes to remove contaminated grains and reduce mycotoxin content in cereals. Winnow out small, shriveled grain which may contain higher levels of mycotoxin than healthy normal grain. Mold infected and/or damaged kernels should be discarded in order to prevent their entry into the food chain and feed manufacturing process.

47. It is important that the cereal lot is tested for mycotoxin concentration before going into further processing, especially when the risk of mycotoxin contamination is high. Lots containing higher levels of mycotoxin should undergo processing that significantly decreases mycotoxin levels to guarantee a safe product to consumers.

48. Brushing, scouring and peeling the grain significantly reduce mycotoxin content, as the outer parts of the kernel contain higher mycotoxin levels or adhering contaminated dust.

49. Dry milling processing of grain can reduce the mycotoxin content of milled products used as food ingredients. Wet milling of maize grain isolates most mycotoxins from the starch fraction used as food ingredients.

50. Avoid keeping flour for long periods of time, but if it is unavoidable then it should be stored in proper storage containers and conditions at safe moisture levels with minimum temperatures changes. Such containers must deter insect and rodent infestation.

51. For products that pass through to the fermentation step, poorly preserved starter cultures are significant sources of mycotoxin contamination. The starter cultures should be maintained pure, viable and sealed to prevent water entrance and other contamination.

52. All processes should follow good hygiene practices and GMP. The HACCP system is an important tool to define which steps of the processing should be controlled to minimize the presence of mycotoxins in food and feed.

ANNEX 1

PREVENTION AND REDUCTION OF CONTAMINATION BY ZEARALENONE IN CEREAL GRAINS

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

1. Good Agricultural Practice and Good Manufacturing Practice include methods to reduce *Fusarium* infection and zearalenone production in cereals in the field and during planting, harvest, storage, transport and processing.

Planting

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

Preharvest

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

4. The establishment of *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 preharvest samples may need to be determined. Utilization of the crop should be based on prevalence of infection and mycotoxin content of the grain.

5. Zearalenone risk in wheat increases with preharvest rainfall. Predictive modelling may be useful to plan to harvest grain before wet weather conditions may emerge.

Harvest

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

Drying and Cleaning

7. Refer to paragraphs 27-30 in the General Code of Practice.

Storage after Drying and Cleaning

8. Refer to paragraphs 31-42 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 46-52 in the General Code of Practice.

ANNEX 2

PREVENTION AND REDUCTION OF CONTAMINATION BY FUMONISINS IN CEREAL GRAINS

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

1. Good Agricultural Practice and Good Manufacturing Practice include methods to reduce *Fusarium* infection and fumonisin contamination of cereals in the field and during planting, harvest, storage, transport and processing.

Planting

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

Preharvest

3. Refer to paragraphs 17-22 in 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 may be used for planning the best harvest time.

Drying and Cleaning

6. Refer to paragraphs 27-30 in the General Code of Practice.

Storage after Drying and Cleaning

7. Refer to paragraphs 31-42 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 46-52 in the General Code of Practice.

10. Nixtamalization, a process that involves boiling and soaking maize in a solution of calcium hydroxide, may reduce fumonisin levels in tortillas and other maize 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 PRACTICE (GMP)

1. Good Agricultural Practice and Good Manufacturing Practice include methods to reduce *Aspergillus* and *Penicillium* infection and ochratoxin A contamination of cereals in the field and during planting, harvest, storage, transport and processing.

Planting

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

Preharvest

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

4. Factors during preharvest that may affect levels of ochratoxin A in harvested grains include frost damage, presence of competitive fungi, excessive rainfall and drought stress.

Harvest

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

Drying and Cleaning

6. Refer to paragraphs 27-30 in the General Code of Practice.

7. Ochratoxin A is produced in cereals due to poor drying or storage conditions. Grain should be allowed to dry as much as possible before harvest in a way consistent with the 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 immediately after the harvest and as fast as possible. In a temperate climate region, when intermediate or buffer storage is necessary because of low drying capacity, make sure that the moisture content is less than 16%, 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

8. Refer to paragraphs 31-42 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 46-52 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 PRACTICE (GMP)

1. Good Agricultural Practice and Good Manufacturing Practice includes methods to reduce *Fusarium* infection and trichothecene contamination of cereals in the field and during planting, harvest, storage, transport and processing.

Planting

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

Preharvest

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

4. Use predicting models developed for DON, which may assist producers in decisions on the necessity and timing of fungicides 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 preharvest samples may need to be determined. Utilization 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 avoid T-2 and HT-2 toxin formation. These toxins are not usually found in grains at harvest, but can result from grains that are water-damaged in the field or grains that become wet at harvest or during storage.

Drying and Cleaning

7. Refer to paragraphs 27-30 in the General Code of Practice.

Storage after Drying and Cleaning

8. Refer to paragraphs 31-42 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 46-52 in the General Code of Practice.

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

ANNEX 5

PREVENTION AND REDUCTION OF CONTAMINATION BY AFLATOXINS IN CEREAL GRAINS

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

1. Good Agricultural Practice and Good Manufacturing Practice includes methods to reduce *Aspergillus* infection and aflatoxin production in cereals in the field and during planting, harvest, storage, transport and processing.

Planting

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

Preharvest

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

4. Biological control can be used for aflatoxins, but the product must be approved by relevant authorities, safe, and cost-effective towards the targeted plant pathogen.

Harvest

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

Drying and Cleaning

6. Refer to paragraphs 27-30 in the General Code of Practice.

7. 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 as the result of poor storage practice. Grain should be allowed to be as dry as possible before harvest in a way consistent with the 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 immediately after the harvest and as fast as possible. In temperate climate region, when intermediate or buffer storage is necessary because of low drying capacity, make sure that the moisture content is less than 16%, 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

8. Refer to paragraphs 31-42 in the General Code of Practice.

9. The formation of aflatoxins in cereals should be prevented during storage by minimizing the time between harvest and drying for storage and transport and maintaining the moisture content at a safe level.

Transport from storage

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

Processing

11. Refer to paragraphs 46-52 in the General Code of Practice.

[ANNEX 6

PREVENTION AND REDUCTION OF CONTAMINATION BY ERGOT AND ERGOT ALKALOIDS IN CEREAL GRAINS

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

1. Good Agricultural Practice includes methods to reduce *Claviceps* fungal infection and ergot alkaloid contamination in cereals in the field and during planting, harvest, storage, transport and processing.

Planting

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

3. Work the soil by turning it over, when the preceding crop (in the rotation) has been rye; as far as is possible, the working of the soil should involve use of a plough. For cases in which the soil is worked without using a plough, the incision into the soil should be deeper than 5 cm.

4. When selecting varieties, avoid varieties susceptible to ergot.

5. When cultivating hybrid varieties with higher susceptibility to ergot, admixture of population varieties is an option to consider. Take into account the climate conditions of the given location.

6. Select the thickness and depth of seed, distances between rows, the density of sown material, fertiliser and use of growth regulator, on the basis of adapting to the specific situation, so as to attain an even and rapid blossoming of the crop and to avoid late-bolting

7. Lay sufficiently wide tramlines for agricultural vehicles.

8. Sow seed of high quality, free of ergot.

9. Combat inferior grasses within the cereal under cultivation and also employ a higher level of crop hygiene at the field's edge: ensure effective care of the margin; combat host plants

Preharvest

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

11. Make a pre-harvest assessment of the cultivated product, regarding the incidence of ergot infestation, as a tool in deciding what to use the harvested product for.

12. Consider a partial harvesting of the crop as an option: separately thresh field/subsections with a high incidence of ergot, in a way that is safe for humans or animals.

Harvest

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

14. There should be a visual check made on the harvested particles and also an air-stream cleaning during the harvest so as to remove infected dust.

15. Remove materials detached in cleaning, and also cereal dust, in good order and according to established professional practice; eliminate them in a way that takes them out of the processing chain of activities

Drying and Cleaning Processing at Farm Level

16. Refer to paragraphs 27-30 in the General Code of Practice.

17. Avoid movement of a product consignment contaminated by ergot; there is a major danger of rub-off and also of adhesive particles of ergot dust. Eliminate all dust particles in each stage of the value-added chain in such a way that they are withdrawn before the next stage in the processing chain.

Storage

18. Refer to paragraphs 31-42 in the General Code of Practice.

Transport from storage

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

Processing

20. Refer to paragraphs 46-52 in the General Code of Practice.

21. In the case of rye, carry out “white cleaning” process (scrubbing, brushing or peeling). Eliminate and dispose of rubbed-off material and also dust generated from taking receipt of the product and from cleaning activities.**]**

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