Foreword

This Code of Practice (COP) for the Prevention and Reduction of Mycotoxin Contamination in Cereals was developed to assist farmers/producers to comply with the maximum levels (MLs) of mycotoxins in cereals, particularly aflatoxins, fumonisins and deoxynivalenol (DON). This Philippine National Standard (PNS) is an adoption of the COP for the Prevention and Reduction of Mycotoxin Contamination in Cereals, including Annexes on Ochratoxin A, Zearalenone, Fumonisins, and Tricothecenes (CAC/RCP 51-2003) of the Codex Alimetarius Commission (CAC), with modifications to suit the local production and post-production practices in the Philippines, particularly for rice and corn. In the preparation of this standard, the following Philippine National Standards (PNS) were considered:

1. PNS/BAFPS 10:2004 Grains – Corn (Zea mays indentata Linn, Zea mays indurate Linn. and Zea mays ceritina K. Sturt. Syn. praecox) – Grading and Classification;
2. PNS/BAFPS 15:2004 Corn (Maize) grits (Zea mays Linn.) – Grading and Classification;
3. PNS/BAFPS 20:2008 Code of Good Agricultural Practices for Corn;
4. PNS/BAFPS 27:2008 Code of Practice for the Prevention and Reduction of Aflatoxin Contamination in Corn; and
5. PNS/BAFS 141:2014 Code of Good Agricultural Practices for Rice

A Technical Working Group (TWG) was created through Special Order No. 106 Series of 2014 to develop the COP for the Prevention and Reduction of Mycotoxin Contamination in Cereals. The TWG represented the relevant agencies of the Department of Agriculture (DA), Department of Science and Technology (DOST), University of the Philippines Los Banos (UPLB) and private sector organizations. Public consultations were conducted in Regions 2, 7, 10, and the National Capital Region (NCR), which represented the major hubs of cereal production and trade in the country. Comments and recommendations were solicited from relevant government agencies, academe, private sector and non-government organizations. Therefore, this COP is the final output of the public-private sector collaboration between and among the TWG, and relevant stakeholders that participated in the public consultations.

Introduction

Mycotoxins are fungal metabolites present in a large part of the world's food supply that pose as threat to human and animal health. The five (5) most important naturally occurring mycotoxins in human food and animal feeds are aflatoxin caused by *Aspergillus flavus* and *A. parasiticus*; ochratoxin A (OTA) by *A. ochraceus* and *Pennicilliun verrucosum*; deoxynivalenol (DON) by *Fusarium graminearium*; zearalenone by *F. graminearium* and *F. culmorum*; and fumonisins by *Fusarium verticillioides*, *F. proliferatum*, and *F. moniliforme*.

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 postharvest mycotoxin contamination in cereals. The list of major mycotoxin-producing fungi that infect cereals during pre-harvest and postharvest can be found in Annex A.

Mycotoxins are potent carcinogens, which can produce both acute and chronic toxicities ranging from deleterious effects in the central nervous, cardiovascular and pulmonary systems and the alimentary tract that may finally result in death. Human diseases like liver and esophageal cancer are associated with aflatoxins and fumonisins, respectively.

The Codex Alimentarius Commission (CAC) has set the Maximum Levels (MLs) for the different mycotoxins for cereals and cereal-based food and feed products, which can be found in the Codex General Standard for Contaminants and Toxins in Food and Feed.

The complete elimination of mycotoxin producing organism might be difficult in humid environments. The elaboration and acceptance of this COP will provide uniform guidance to consider in attempting to control and manage organisms responsible for the mycotoxin contamination in cereals. It is important for farmers/producers to realize that Good Agricultural Practices (GAP) and Good Manufacturing Practices (GMP) represent the primary lines of defense against mycotoxin contamination of cereals during pre-harvest and post-harvest stages.

1 Scope

This Code for the prevention and reduction of mycotoxins in cereals 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 in production, storage, handling, transportation, processing, distribution and trade.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CAC/RCP 51-2003 (Amd. 2017), *Code of practice for the prevention and reduction of mycotoxin contamination in cereals*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
cereals
crops belonging to the genera and species of the grass family (Gramineae) used for food and feeds, which include but not limited to rice, corn, Job's tears (adlai), sorghum, barley, oats, rye, and wheat

3.2
grains
kernels remaining after removal of inedible parts such as the husk or hull, which can be used intact (e.g., brown rice/milled rice, corn kernel), cracked (e.g., corn grits), ground (e.g., wheat flour), or flaked (e.g., breakfast cereal)

3.3
mycotoxins
diverse group of toxic chemical substances (secondary metabolites) produced by fungi

3.3.1
aflatoxin
group of highly poisonous and carcinogenic compounds, which are produced by strains of the fungi, *Aspergillus flavus* and *A. parasiticus*, on suitable substrates such as corn, peanuts, cassava, copra and other oilseeds

3.3.2
deoxynivalenol (DON)

commonly called vomitoxin, is produced by several fungi of the genus *Fusarium*, specifically *F. graminearium,* frequently infecting rice, corn, barley, oats, and other cereals in the field or during postharvest operations

3.3.3
fumonisins
produced by the fungi *Fusarium verticillioides*, *F. proliferatum*, *F. moniliforme* and other *Fusarium* species that grow on agricultural commodities in the field or during postharvest operations

3.3.4
ochratoxin A (OTA)
produced by fungi belonging to the genera *Aspergillus* and *Penicillium*, specifically *A. ochraceus* and *P. verrucosum,* when the nutrients, temperature and water activity required for growth and biosynthesis are present

3.3.5
tricothecenes (T-2)
produced by species that belong to several fungal genera of *Fusarium*, *Stachybotrys*, *Trichothecium*, *Trichoderma*, *Memnoniella*, and *Myrothecium* generally found in various cereal crops such as corn, barley, oats, rye, wheat and processed grains

3.3.6
zearalenone
compound produced by *Fusarium* spp. such as *F. graminearium* and *F. culmorum* found specifically as a contaminant in corn but may also occur in sorghum, barley, oats, and wheat

3.4
pre-harvest stages
stages in the cereal food supply chain which includes planting, pest and weed management, irrigation, and harvesting

3.5
post-harvest stages
refers to the stages in the cereal food supply chain involving the minimal transformation of cereals after primary production such as shelling/threshing/drying, sorting/cleaning, storage, and transport of the grains

4 Good Agricultural Practice (GAP)

4.1 Pre-harvest

4.1.1 Planting and crop rotation

A crop rotation schedule should be developed and maintained 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.

The most susceptible crops to toxigenic fungi and the mycotoxins that can be produced are shown in Annex B.

Crops of low susceptibility to toxigenic fungi such as potato, mungbean, soybean, and other legumes can be used in rotation to reduce the inocula in the field.

When possible and practical, toxigenic fungi free certified seeds should be used and the seed bed should be prepared 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.

In areas that are vulnerable to erosion, no-till or minimum tillage practices may be required in the interest of soil and water conservation.

The results of soil/tissue tests should be utilized 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.

Quality seed varieties adapted to the locality and/or those approved by the National Seed Industry Council (NSIC) should be used.

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 (e.g., weather forecasts and planting patterns), when available, could be used as a tool to plan for the best planting period.

Appropriate density of planting by maintaining the recommended row and intra-row and inter-plant spacing for the species/varieties grown should be ensured. Information concerning plant-spacing may be provided from seed companies, national authorities, or extension services.

Minimize mechanical damage to plants during cultivation, irrigation and pest management practices. Minimize 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.

4.1.2 Pest/weed management

Minimize insect damage and fungal infection in the vicinity of the crop by proper use of registered pesticides and other appropriate practices within an integrated pest management program. Predictive models may be used to plan the best time and mode of pesticide application.

Weeds in the crop should be controlled by use of mechanical methods, registered herbicides or other safe and suitable weed management practices utilizing an integrated pest management program.

4.1.3 Irrigation

If irrigation is used, ensure that it is applied in a timely and even manner so that all plants in the field will have an adequate supply of water. Irrigation during flowering and ripening of crops should be minimized (except for rice). Excess water during flowering makes conditions favorable for proliferation and infection by mycotoxin-producing fungi.

4.1.4 Harvesting

Plan to harvest grain at low moisture content (refer to Annex C) and full maturity. Delayed harvest of grain already infected by *Fusarium* species may cause an increase in the mycotoxin content of the crop.

Before harvest, all equipment to be used for harvesting, drying, cleaning and storage of crops, should be in a good working order and cleaned of crop residues, grain and dust. A breakdown of equipment during this critical period may cause grain quality losses and enhance mycotoxin formation. Important spare parts should be available on the farm to minimize time loss from repairs. Equipment needed for moisture content measurements should be available and calibrated.

Containers (e.g., bags, sacks) 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.

Avoid contact of harvested crop with dirt, soil, and other contaminants. Remove the infected and infested crop from the ground and dispose properly.

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.

4.2 Post-harvest stages

4.2.1 Shelling/Threshing/Drying

Immediately after harvest:

a. Crops should be cleaned and sorted to remove damaged produce and other foreign matters.

b. Shell corn on cob at 18-20% MC and dry the kernels to 13-14% MC or less prior to storage.

c. Thresh rice at 21-24% MC and sorghum at 16-20% MC and dry the grains to 14% MC or less prior to storage.

In the field, do not pile or heap wet and freshly harvested crops for a long period of time prior to shelling/threshing or drying to lessen the risk of fungal growth.

Use recommended mechanical drying facilities or equipment for each commodity. If sun drying, avoid direct contact with soil by use of concrete pavement and underlays.

4.2.2 Storage

Storage facilities (bins, silos, sheds and other buildings intended for grain storage) should be dry, well-ventilated, provide protection from rain, ground water, moisture condensation, and the entry of rodents, birds and insects that cannot only contaminate grain, but damage grain kernels to render them more susceptible to mold infection. Ideally, storage structures should be designed so as to minimize wide fluctuations in the temperature of the stored grain.

Only grains that have passed the food safety and quality standards (i.e., MC, mycotoxin level, and physical qualities) should be stored.

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 nontoxic food-grade materials that do not attract insects or rodents and are sufficiently strong to resist storage for longer periods.

When storing in bulk/silo, aerate the grain by circulating air to maintain proper and uniform temperature, and minimize development of hotspots. Check MC and temperature of the stored grains at regular fixed time intervals. A temperature rise of 2-3°C may indicate microbial growth and/or insect infestation.

Observe good warehousing practices in accordance with PNS/BAFS 193:2017 Good warehousing practices for bagged grains.

4.2.3 Transport

Transport facilities, including container vans, trucks, railway cars, and vessels (boats and ships) should be clean and dry before use. They should be disinfected/disinfested with appropriate substances and registered fumigants or pesticides (i.e., should not cause off-odors, off-flavor or contaminate the grains). At unloading, the transport container should be emptied of all cargo and cleaned as appropriate.

Shipments of bagged grains should be protected from additional moisture by using tarpaulin covers. Minimize temperature fluctuations that may cause condensation to

form on the grain, which could lead to local moisture build-up and consequent fungal growth and mycotoxin formation.

Prevent insect, bird, and rodent infestation during transport by the use of insect-and-rodent proof containers or insect and rodent repellant chemical treatments approved for the intended end use of the grains.

4.2.4 Sorting/Cleaning

Sorting and cleaning should be done to remove visibly moldy infected and/or damaged kernels to reduce formation and contamination of mycotoxin and its further entry into the food and livestock feed supply chains.

4.3 Recordkeeping

Records of farming operations such as production practices, harvesting and storage procedures implemented, and environmental conditions (e.g., temperature, moisture, and humidity) should be kept for traceability purposes.

Annex A
(informative)

Major mycotoxin-producing fungi infecting cereals during pre-harvest and postharvest

Type of fungi	Genus	Mycotoxins
Field Fungi	*Fusarium*	beauvericin, deoxynivalenol (DON), enniatins, fumonisins, HT-2 toxin, moniliformin, T-2 toxin, zearalenone
Storage Fungi	*Aspergillus*	Aflatoxins, Ochratoxin A (OTA)
	Penicillium	Ochratoxin A (OTA)

Annex B
(informative)

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*	deoxynivalenol, ergot alkaloids

Crops	Fungi	Potential of mycotoxins
	Claviceps purpurea	
Cotton	*A. flavus* *A. parasiticus*	Aflatoxins
Millet	*F. graminearum*	Deoxynivalenol
Triticale	*F. graminearum*	Deoxynivalenol

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Annex C
(informative)

Recommended moisture content (MC) for harvesting of cereals

Cereal crop	MC, Percent (%)	Reference
Rice	21 – 24	http://www.fao.org/fileadmin/user_upload/inpho/docs/Post_Harvest_Compendium_-_RICE.pdf
Corn/Maize	18 - 24	http://www.fao.org/docrep/t0395e/T0395E04.htm
Sorghum	16 – 20	http://www.fao.org/fileadmin/user_upload/inpho/docs/Post_Harvest_Compendium_-_SORGHUM.pdf

Bibliography

Codex Code of Practice for the Prevention and Reduction of Mycotoxin Contamination in Cereals, Including Annexes on Ochratoxin A, Zearalenone, Fumonisins and Tricothenes (CAC/RCP 51-2003).

Codex Code of Practice for the Prevention and Reduction of Ochratoxin A (OtA) Contamination in Coffee (CAC/RCP 69:2009).

Codex General Standard for Contaminants and Toxins in Food and Feed (Codex Stan 193-1999)

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

Hazard Analysis and Critical Control Points (HACCP) and Guidelines for its Management - CAC/RCP 1-1969 Rev (2003).

http://www.darfu4b.da.gov.ph/pub.html

http://www.fao.org/docrep/005/y1390e/y1390e02.htm#bm02x

http://www.fao.org/fileadmin/user_upload/inpho/docs/Post_Harvest_Compendium_-_MAIZE.pdf

http://www.fao.org/fileadmin/user_upload/inpho/docs/Post_Harvest_Compendium_-_RICE.pdf

http://www.fao.org/fileadmin/user_upload/inpho/docs/Post_Harvest_Compendium_-_SORGHUM.pdf

http://www.fao.org/waicent/faoinfo/economic/faodef/fdef01e.htm

http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/ChemicalContaminantsMetalsNaturalToxinsPesticides/ucm120184.htm

http://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/ucm109231.htm

http://www.food.gov.uk/policy-advice/mycotoxins/animalfeed/
http://www.healthgrain.org/webfm_send/44

http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2635619

http://www.vkm.no/dav/eee04d10c4.pdf

Leslie, John F., Bandyopadhyay and Angelo Visconti. 2008. Mycotoxin: Detecting Methods, Management, Public Health and Agricultural Trade. United Kingdom: CAB International.

Mills John T. 1989. Mycotoxin and Toxigenic Fungi in Cereal Grains in Western Canada, Agriculture Canada Research Station, Winnipeg Canada.

Norwegian Scientific Committee for Food Safety. 2013. Risk Assessment of Myxotoxin in Cereal Grain in Norway.

PNS/BAFPS 20:2008 Code of Good Agricultural Practices for Corn

PNS/BAFS 141:2014 Code of Good Agricultural Practices for Rice

PNS/BAFPS 27:2008 Code of Practice for the Prevention and Reduction of Aflatoxin Contamination in Corn

PNS/BAFPS 15:2004 Corn (Maize) grits (*Zea mays Linn.)* – Grading and Classification

PNS/BAFPS 10:2004 Grains – Corn (*Zea mays indentata Linn, Zea mays indurate Linn.* and *Zea mays ceritina K. Sturt.* Syn. *praecox*) – Grading and Classification

Report of the Eight Session of the Codex Committee on Contaminants in Foods (CCCF), 2014

Republic Act 10611: Food Safety Act of 2013