

Code of Practice for the Prevention and Reduction of Mycotoxin Contamination in Cereals**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, Fumonisin, and Tricothecenes (CAC/RCP 51-2003) of the Codex Alimentarius 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. Grains – Corn (*Zea mays indentata* Linn, *Zea mays indurata* Linn. and *Zea mays ceritina* K. Sturt. Syn. *praecox*) – Grading and Classification (PNS/BAFPS 10:2004);
2. Corn (Maize) grits (*Zea mays* Linn.) – Grading and Classification (PNS/BAFPS 15:2004);
3. Code of Good Agricultural Practices for Corn (PNS/BAFPS 20:2008);
4. Code of Practice for the Prevention and Reduction of Aflatoxin Contamination in Corn (PNS/BAFPS 27:2008); and
5. Code of Good Agricultural Practices for Rice (PNS/BAFS 141:2014).

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.

Code of Practice for the Prevention and Reduction of Mycotoxin Contamination in Cereals**I. INTRODUCTION**

1. 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 *Penicillium verrucosum*; deoxynivalenol (DON) by *Fusarium graminearum*; zearalenone by *F. graminearum* and *F. culmorum*; and fumonisins by *Fusarium verticillioides*, *F. proliferatum*, and *F. moniliforme*.
2. The mycotoxin-producing fungi that infect cereals can be or are present in the field during primary production (planting, pre-harvest management practices) and/or during post-production operations (harvesting, threshing/shelling, drying, on/off-farm storage, transport/distribution and milling). The list of important mycotoxin-producing fungi that infect cereals during growing season and storage can be found in **Annex 1**.
3. 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. A summary of mycotoxins for which exposure estimates or exposure scenarios have been made, in terms of No Observed Adverse Effect Level (NOAEL) or Lowest Observed Adverse Effect Levels (LOAEL) in animals together with critical effects and the Tolerable Daily Intake (TDI) can be found in **Annex 2**.
4. 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 **Annex 3**.
5. The complete elimination of mycotoxin producing organism is not achievable with the tropical conditions prevailing in the country. 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 primary production, post-harvest stages and distribution.

Code of Practice for the Prevention and Reduction of Mycotoxin Contamination in Cereals**II. SCOPE**

6. This COP contains on-farm and off-farm practices for the prevention and/or reduction of mycotoxin contamination in cereals used for food and feeds, and serves as basis for monitoring and regulation by competent authorities. The recommended practices are based on GAP and GMP in addition to the Hazard Analysis and Critical Control Points (HACCP)/Hazard Analysis and Risk Based Preventive Control (HARBPC) or equivalent processes.

III. DEFINITIONS

For the purpose of this Code, the following terms are operationally defined:

Cereals – refer to crops belonging to the genera and species of the grass family (Gramineae) used for food and feeds, which include barley, corn, job’s tears (adlai), oats, rice, rye, sorghum and wheat.

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

Mycotoxins – are a diverse group of chemical substances (secondary metabolites) produced by fungi. The major mycotoxins in cereals are the following:

Aflatoxins – a 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 cassava, copra and other oilseeds, corn and peanuts.

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

Fumonisin – 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.

Ochratoxin A (Ota) – is the toxic metabolite produced by fungi belonging to the genera *Aspergillus* and *Penicillium* specifically *A. ochraceus* and *P. verrucosum* when the

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nutrients, temperature and water activity required for growth and biosynthesis are present.

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

Zearalenone – is the compound produced by *Fusarium spp.* such as *F. graminearum* and *F. culmorum* found specifically as a contaminant in corn but may also occur in barley, oats, sorghum, and wheat.

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

IV. GOOD AGRICULTURAL PRACTICE (GAP)**PRE-HARVEST*****Planting***

7. Develop and maintain a crop rotation schedule in order to reduce the inocula in the field. Crops that are not host to mycotoxin-producing fungi species should be used (e.g. potato and mungbean).
8. Where practical and possible, prepare the area for each new crop by plowing under or by destroying or removing old seed heads, stalks, and other debris that may serve, 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 conservation.
9. Utilize the results of soil/tissue analyses to determine if there is a need to apply fertilizer and/or soil conditioners to ensure attainment of optimum soil pH and adequate plant nutrition to avoid plant stress.
10. Use quality seed varieties adapted to the locality and/or those approved by the National Seed Industry Council (NSIC).

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11. As much as possible, 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, may be used as a tool to plan for the best planting period.
12. Ensure appropriate density of planting by maintaining the recommended row and intra-plant spacing for the species/varieties grown (please refer to **Annex 4**). Information concerning plant-spacing may be obtained from seed companies or authorized bodies.

Pest/Weed Management

13. 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 application time for pesticides.
14. Control weeds in the crop by use of mechanical methods, registered herbicides or other safe and suitable weed management practices.

Irrigation

15. 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 avoided (except for rice). Excess water during flowering makes conditions favorable for proliferation and infection by mycotoxin-producing fungi.

HARVESTING

16. Plan to harvest the cereal crop at full maturity and at recommended low moisture content or MC (please refer to **Annex 5**). Delayed harvest of grains may subject them to rainfall, which may cause a significant increase in mycotoxin contamination.
17. Ensure that all equipment to be used for harvesting and storage of harvested produce are operational. Breakdowns during these critical periods may cause losses in grain quality and increase mycotoxin contamination. Keep important spare parts available on the farm to minimize time lost during repairs. Make sure that calibrated equipment for MC measurement is always available.

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18. Use clean and dry bags or sacks for collection and transport of harvested crops from field to the drying and storage facilities.
19. Avoid contact of harvested crop with dirt, soil, and other contaminants. Remove the infected and infested crop from the ground and dispose properly.

POST-HARVEST STAGES***Shelling/Threshing/Drying***

20. Immediately after harvest:
 - a. Crops should be cleaned and sorted to remove damaged produce and other foreign matters.
 - b. Shell corn on cob at 21% MC and dry the kernels to 14% MC or less prior to storage.
 - c. Thresh rice and sorghum at 18% MC and dry the grains to 14% MC or less prior to storage.
21. 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.
22. Use recommended mechanical drying facilities or equipment for each commodity. If sun drying, avoid direct contact with soil by use of surfaces and underlays.

Storage

23. Storage facilities should be well-ventilated, with protection from entry of rodents, birds, insects, rain, ground water seepage, and provision for drainage.
24. Store only grains that have passed the food safety and quality standards (i.e. MC, mycotoxin level, and physical qualities).
25. Use clean and dry bags to store the crop or grain and pile them on pallets.
26. 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.

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27. Use good housekeeping procedures to minimize of insects and fungi in the storage facilities. This may include the use of suitable, registered insecticides and fungicides or appropriate alternative methods within an integrated pest management program.

Transport

28. Transport facilities, including container vans, 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).
29. When transporting grains in bags, use tarpaulin to cover the shipment and protect them from rain and mycotoxin accumulation.
30. Prevent insect, bird, and rodent infestation during transport by the use of insect-and-rodent proof containers or insect and rodent repellent chemical treatments approved for the intended end use of the grains.

Sorting/Cleaning

31. When applicable, sort to remove physically damaged and discolored grains to reduce formation or contamination of mycotoxin, and its further entry into the food chain and feed manufacturing process.

V. RECORD KEEPING

32. Keep record of farming operations such as production practices, harvesting and storage procedures implemented, and environmental conditions (e.g., temperature, moisture, and humidity).

Code of Practice for the Prevention and Reduction of Mycotoxin Contamination in Cereals**REFERENCES:**

Codex Code of Practice for the Prevention and Reduction of Mycotoxin Contamination in Cereals, Including Annexes on Ochratoxin A, Zearalenone, Fumonisin and Tricothene (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>

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

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

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

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

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

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<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>

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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 Mycotoxin in Cereal Grain in Norway.

Philippine National Standard: Code of Good Agricultural Practices for Corn (PNS/BAFPS 20:2008).

Philippine National Standard: Code of Good Agricultural Practices for Rice (PNS/BAFPS 141:2014).

Philippine National Standard: Code of Practice for the Prevention and Reduction of Aflatoxin Contamination in Corn (PNS/BAFPS 27:2008).

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

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

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

Republic Act 10611: Food Safety Act of 2013.

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Annex 1

The Most Important Mycotoxin-Producing Fungi Infecting Cereals
During Growing Season and Storage

Type of Fungi	Genus	Mycotoxins
Field Fungi	<i>Fusarium</i>	beauvericin, deoxynivalenol, (DON), enniatins, fumonisins, HT-2 toxin, moniliformin, T-2 toxin, zearalenone
Storage Fungi	<i>Aspergillus</i>	Aflatoxins, Ochratoxin A (OtA)
	<i>Penicillium</i>	Ochratoxin A (OtA)

Reference: <http://www.vkm.no/dav/eee04d10c4.pdf>

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Annex 2

The No Observed Adverse Effect (NOAEL) /Lowest Observed Adverse Effect Level (LOAEL)
in Animals

Mycotoxin	Critical Effect	NOAEL¹/LOAEL² (mg/kg bw/day)	Tolerable Daily Intake³ (ug/kg bw/kg)
DON	Reduced feed intake and weight gain	0.1 (NOAEL)	1.0
T-2 + HT-2	Immunotoxicity/ haematotoxicity	0.03 (LOAEL)	0.1
Nivalenol	Reduced growth, leucopenia	0.7 (LOAEL)	0.7
Zearalenone	Oestrogenic activity	0.01 (NOAEL)	0.25

1) NOAEL – No Observed Adverse Effect Level

2) LOAEL – Lowest Observed Adverse Effect Level

3) Tolerable Daily Intake, TDI, is a term used by EFSA, while JECFA uses the term Provisional Maximal daily Intake (PMTDI)

Reference: <http://www.vkm.no/dav/eee04d10c4.pdf>

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Annex 3

Maximum Levels of Mycotoxins in Cereals and Cereal-Based Products for Food and Feeds

Mycotoxin	Cereals and Cereal-Based Products	Maximum Levels (MLs) ug/kg or ppb		Reference
		Food	Feed	
<i>Aflatoxin</i>	Raw corn grains	20	50	PNS/BAFPS 10:2004
	Corn grits	20	50	PNS/BAFPS 15:2004
<i>OchratoxinA (OtA)</i>	Raw wheat, barley and rye	5	No value established	CODEX Standard 193-1995
<i>Fumonisin</i>	Raw corn grains	4000	No value established	Report of the Eight Session of the Codex Committee on Contaminants in Foods (CCCF), 2014
	Corn flour and meal	2000	No value established	
<i>Deoxynivalenol (DON)</i>	Cereal-based food for infants and young children	200	No value established	
	Raw cereal grains (wheat, corn, and barley)	2,000	No value established	
	Flour, semolina, flakes derived from wheat, corn and barley	1,000	No value established	

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Annex 4

Recommended Row and Intra-Plant Spacing

Cereal Crop	Row and Intra-Plant Spacing (cm)
Rice	20 x 15 – 20
Corn	75 x 20 – 25

Reference: <http://www.darfu4b.da.gov.ph/pub.html>

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Annex 5

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	35 - 40	http://www.fao.org/fileadmin/user_upload/inpho/docs/Post_Harvest_Compendium - MAIZE.pdf
Sorghum	16 - 20	http://www.fao.org/fileadmin/user_upload/inpho/docs/Post_Harvest_Compendium - SORGHUM.pdf