PHILIPPINE NATIONAL STANDARD

PNS/BAFS 146:2019
ICS 65.020

Code of practice for the prevention and reduction of mycotoxin contamination in cereals

BUREAU OF AGRICULTURE AND FISHERIES STANDARDS
BPI Compound Visayas Avenue, Diliman, Quezon City 1101 Philippines
Trunkline: **(632) 928-8741 to 64 loc. 3301-3319**
E-mail: **info.dabafs@gmail.com**
Website: **www.bafs.da.gov.ph**

Foreword

The Philippine National Standard (PNS) Code of Practice (COP) for the Prevention and Reduction of Mycotoxin Contamination in Cereals was developed in 2015 and reviewed together with other corn-related standards in 2017 by the Bureau of Agriculture and Fisheries Standards (BAFS) to check if its provisions are still relevant and effective to the current regulatory and market needs. It has been revised by the Technical Working Group (TWG) for the review of various PNS related to corn as per Department of Agriculture Special Order Nos. 301 and 814 Series of 2017. This Standard has been approved by the Secretary of the Department of Agriculture in 2019.

In the revision of this Standard, the CAC/RCP 51-2003 Code of Practice for the Prevention and Reduction of Mycotoxin Contamination in Cereals amended in 2017 was used as a major reference.

This PNS/BAFS 146:2019 cancels and replaces PNS/BAFS 146:2015 which has been technically revised.

This edition includes the following significant changes compared to the previous edition:

- deletion of annex on the no observed adverse effect (NOAEL)/lowest observed adverse effect level (LOAEL) in animals; maximum levels of mycotoxins in cereals and cereal-based products for food and feeds; recommended row and intra-plant spacing; and recommended moisture content for harvesting of cereals;
- inclusion of annex (Annex C) on rotation crops susceptible to toxigenic fungi associated with production of mycotoxins (not exhaustive); and
- revision of moisture content for shelling of corn and threshing of rice and sorghum.

This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2.

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 stored grains, in the dust in drying and/or storage facilities, in soils, in wild host plant species, and in the residues of cultivated crops. 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 cancers and nephropathy are associated with mycotoxins.

The Codex Alimentarius Commission (CAC) has set the Maximum Levels (MLs) for the different mycotoxins for cereals and cereal-based food and feed products. These 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.

Code of practice for the prevention and reduction of mycotoxin contamination in cereals

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 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.

PNS/BAFS 193, *Good Warehousing Practices (GWP) for Bagged Grains*

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 paddy rice, corn, Job's tears (adlai), sorghum, barley, oats, rye, and wheat

3.2
crop rotation
practice of growing a series of different types of crops in the same area in successive seasons, including fallowing, to break weed, pest, and disease cycles and to maintain or improve soil fertility and organic matter content

3.3
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)

3.4
mycotoxins
diverse group of toxic chemical substances (secondary metabolites) produced by fungi (e.g. aflatoxin, ochratoxin A, deoxynivalenol (DON), zearalenone, fumonisins (see Annex B))

3.5
production stages
stages in the cereal food supply chain which includes field preparation, planting, pest and weed management, fertilization, irrigation, and harvesting

3.6
post-harvest stages
stages in the cereal food supply chain involving the minimal transformation of cereals after production stage such as dehusking and shelling in corn, threshing, drying, sorting/cleaning, storage, and transport of the grains

4 Good Agricultural Practice (GAP)

4.1 Production stages

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 more than 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 C.

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 competent authority should be used.

As far as practical, planting should be timed with optimum rainfall availability for critical growth stages of the crop. Predictive models (e.g. weather forecasts and planting patterns) could be used as tools 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. 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 could be controlled by mechanical methods, responsible use of 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 is a valuable method of reducing plant stress during flowering and early stages of grain development.

4.1.4 Harvesting

Harvest the crop immediately at full maturity. Delayed harvest of crop 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 good working condition and cleaned of crop residues and dirt. A breakdown of equipment during this critical period may cause grain quality losses and enhance mycotoxin formation. Important spare parts should be available in 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 for drying and storage purposes should be clean, dry, and free of crop residues, insects, visible fungal growth, and dirt.

Remove infected and infested crop from the ground and dispose properly.

Avoid piling and heaping of freshly harvested commodities for more than a few hours prior to drying or threshing to lessen the risk of fungal growth. Aerate storage bins containing high moisture grains 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 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 clean concrete pavement and underlays.

4.2.2 Storage

Storage facilities (bins, silos, sheds, and other buildings intended for grain storage) should be dry and well-ventilated. These should provide protection from rain, ground water, moisture condensation, and pests that can lead 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 to facilitate aeration. The bags should be made of nontoxic food-grade materials and are sufficiently strong for long period of storage.

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

Good warehousing practices shall be observed in accordance with PNS/BAFS 193 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). Before unloading, safety

procedures should be practiced to allow sufficient period for the fumigants to dissipate. At unloading, the transport container should be emptied of all cargo and cleaned appropriately.

Bagged grains shall be covered with tarpaulin to protect them from rain and direct sunlight. Temperature fluctuations may cause condensation to form on the grain, which could lead to local moisture build-up and consequent fungal growth and mycotoxin formation.

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.

4.3 Recordkeeping

Records of farming operations, including dates, 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)

Examples of mycotoxins

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

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

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

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

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

Annex C
(informative)

Rotation crops susceptible 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

Crops	Fungi	Potential of mycotoxins
Rye	*F. graminearum* *Claviceps purpurea*	deoxynivalenol, ergot alkaloids
Cotton	*A. flavus* *A. parasiticus*	Aflatoxins
Millet	*F. graminearum*	Deoxynivalenol
Triticale	*F. graminearum*	Deoxynivalenol

Bibliography

CAC/RCP 1-1969 (Rev. 2003), *General Principles of Food Hygiene*

CAC/RCP 51-2003 (Amd. 2017), *Code of Practice for the Prevention and Reduction of Mycotoxin Contamination in Cereals*

Codex Alimentarius Commission. 2014. *Report of the Eighth Session of the Codex Committee on Contaminants in Food.* The Hague: Codex Alimentarius Commission.

CODEX STAN 193-1995, *Codex General Standard for Contaminants and Toxins in Food and Feed*

Food and Agriculture Organization of the United Nations. 2001. Chapter 1: An introduction to mycotoxins. *Manual on the application of the HACCP system in mycotoxin prevention and control.* Retrieved from http://www.fao.org/docrep/005/y1390e/y1390e02.htm#bm02x

Food and Agriculture Organization of the United Nations. 1994. *Definition and classification of commodities: Cereals and cereal products*. Retrieved from http://www.fao.org/waicent/faoinfo/economic/faodef/fdef01e.htm

Leslie, J.F.., Bandyopadhyay, R., & Visconti, A. 2008. *Mycotoxin: Detecting Methods, Management, Public Health and Agricultural Trade*. Oxfordshire: CAB International.

Mills, J.T. 1990. Mycotoxins and toxigenic fungi on cereal grains in western Canada. *Canadian Journal of Physiology and Pharmacology,* 68(7): 982-986. doi: 10.1139/y90-149

Norwegian Scientific Community for Food Safety. 2013. *Risk assessment of mycotoxins in cereal grain in Norway*. Retrieved from https://vkm.no/download/18.2994e95b15cc545071615a36/1510054265635/Risk%20assessment%20of%20mycotoxins%20in%20cereal%20grain%20in%20Norway.pdf

PNS/BAFS 10:2017, *Grains – Grading and classification - Corn*

PNS/BAFS 15:2018, *Corn (maize) grits – Grading and classification*

PNS/BAFS 20:2018, *Good Agricultural Practices for Corn*

PNS/BAFS 27:2018, *Code of practice for the prevention and reduction of aflatoxin contamination in corn*

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

U.S. Food & Drug Administration. 2000. *Guidance for Industry: Fumonisin Levels in Human Foods and Animal Feeds*. Retrieved from https://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/ucm109231.htm

U.S. Food & Drug Administration. 2010. *Guidance for Industry and FDA: Advisory Levels for Deoxynivalenol (DON) in Finished Wheat Products for Human Consumption and Grains and Grain By-Products used for Animal Feed.* Retrieved from https://www.fda.gov/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/ChemicalContaminantsMetalsNaturalToxinsPesticides/ucm120184.htm

Yazar, S. & Omurtag, G.Z. 2008. Fumonisins, trichothecenes and zearalenone in cereals. *International Journal of Molecular Sciences,* 9(11): 2062-2090. doi: 10.3390/ijms9112062

Department of Agriculture
Bureau of Agriculture and Fisheries Standards

Technical Working Group (TWG) for the Review of Various Philippine National Standards (PNS) Related to Corn

Chairperson
Rolando B. Gomez
National Food Authority
Department of Agriculture

Members

1 Arlene F. Tanseco
National Food Authority
Department of Agriculture

2 Jocelyn M. Sales

3 Rachel F. Rocafort
National Food Authority – Food Development Center
Department of Agriculture

4 Miriam A. Acda

5 Efren R. Regpala
Philippine Center for Postharvest Development and Mechanization
Department of Agriculture

6 Artemio M. Salazar

7 Maria Alma B. Sanchez
Institute of Plant Breeding
University of the Philippines – Los Baños

8 Candido B. Damo
National Corn Program
Department of Agriculture

9 Roderico R. Bioco
National Corn Competitiveness Group, Inc.

10 Roger V. Navarro
Philippine Maize Federation, Inc.

Project Manager
Lara V. Navarro
John Gregory V. Aquino
Farlash D. Pancho
Francesca Louise P. Garcia

Bureau of Agriculture and Fisheries Standards

Adviser
Vivencio R. Mamaril

BUREAU OF AGRICULTURE AND FISHERIES STANDARDS

BPI Compound Visayas Avenue, Diliman, Quezon City 1101 Philippines
T/ (632) 928-8741 to 64 loc. 3301-3319
E-mail: info.dabafs@gmail.com
Website: www.bafs.da.gov.ph