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

Kenya Bureau of Standards

Standards for Quality life

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Kenya Agricultural and Livestock Research Organization
National Cereals and Produce Board (NCPB)
Ministry of Agriculture and Livestock Development – State Department of Agriculture
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In order to keep abreast of progress in industry, Kenya Standards shall be regularly reviewed. Suggestions for improvements to published standards, addressed to the Managing Director, Kenya Bureau of Standards, are welcome.

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

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Foreword

This Kenya Standard for Code of practice for the prevention and reduction of mycotoxin contamination in cereals was prepared by the Cereals and Pulses Technical Committee under the guidance of the Standards Projects Committee, and it is in accordance with the procedures of the Kenya Bureau of Standards.

Mycotoxins are secondary metabolites produced by toxigenic fungi. Toxigenic fungi are prevalent in regions in climatic zones which allow for small- and large-scale cereal grain production. Mycotoxin contamination in the country has far-reaching effects on public health, food security, and the economy. Mycotoxins, particularly aflatoxins, are linked to severe health issues. Additionally, contaminated crops are unfit for consumption, leading to food shortages. This is especially critical in a country where cereals like maize are staple foods. Farmers and traders also face financial losses when crops are rejected due to contamination.

To address these challenges, the Technical Committee developed this code of practice that is customized to the Kenyan context so as to help the cereal value chain actors to address the concerns in the sector regarding the prevention and reduction of mycotoxin.

During the preparation of this standard, reference was made to the following documents:

CAC/RCP 51: 2016- Code of practice for the prevention and reduction of mycotoxin contamination in cereals

INTRODUCTION

Mycotoxins are secondary metabolites produced by toxigenic fungi. 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.

Mycotoxin contamination in the country has far-reaching effects on public health, food security, and the economy. Mycotoxins, particularly aflatoxins, are linked to severe health issues. Additionally, contaminated crops are unfit for consumption, leading to food shortages. This is especially critical in a country where cereals like maize are staple foods. Farmers and traders also face financial losses when crops are rejected due to contamination.

Cereals play a significant role in Kenya's food security and dietary habits. They are a primary source of energy and nutrition for millions of Kenyans, forming the foundation of many traditional and modern meals. Staple cereals such as maize, wheat, rice, sorghum, and millet are cultivated across the country, with maize being the most widely grown and consumed. Cereals also drive economic activity in the country providing livelihoods for farmers, traders, and millers. With Kenya's growing population, cereals remain at the heart of the nation's agricultural sector and food culture.

This Code of practice for the prevention and reduction of mycotoxins in cereal grains and grain-derived foods and feeds recommends good agricultural practices (GAP), good manufacturing practices (GMP) and other principles during the farming, handling, storage, processing and distribution of cereals. The code also aims at minimizing mycotoxin contamination through application of preventive control measures to the extent feasible, mainly during storage and processing. This will ensure that mycotoxin levels are within the limits recommended in commodity standards.

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

1 Scope

This draft Kenya code of practice provides the requirements and general recommended practices for the prevention and reduction of mycotoxin contamination in cereals.

This document is applicable to farmers, industry regulators, researchers and other cereal value chain actors.

2 Normative references

The following referenced documents are indispensable for the application 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.

KS EAS 900 Cereals and pulses – Sampling

KS EAS 901 Cereals and Pulses - test methods

KS 2754 Code of practice for Cereals and Pulses

3 Terms and definitions

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

3.1 conditioning

addition of moisture to dried grains

3.2 food

any substance, whether processed, semi-processed or raw, which is intended for human consumption

3.3 water activity

in foods it is the water that is not bound to food molecules (such as milled grain products) that can support the growth of bacteria, yeasts, and fungi

3.4 soil sanitation

for mycotoxin in the field is the management of the fields to prevent mould growth and reduce mycotoxin contamination. This includes proper soil management, crop rotation and use of biological controls to suppress toxin producing fungi

3.5 lodging

in plants refers to permanent displacement of a stem or part of the stem from vertical position

3.6 Swaths

a row or line of grass, corn or other crops as it falls or lies when mowed or reaped mechanically

3.7 Rouging

uprooting of unwanted weeds from the main crop field

4. General requirements

Good Agricultural Practices (GAP) and Good Manufacturing Practices (GMP) should be observed across the cereal value chains.

Production and handling of cereals should be done in accordance with the code of practice for cereals and pulses KS 2754,

4.1 Personnel Competence

Training shall be done to ensure competence of the cereal grain handlers.

4.2 Sampling and testing

Sampling and testing shall be done at all relevant stages to ascertain the levels of mycotoxin contamination and moisture content in the cereals.

4.3 Equipment maintenance and calibration

Equipment used in production and handling of cereals shall be regularly cleaned , well maintained and calibrated.

5. Specific requirements

5.1 Land management

Good agricultural practices (GAPs) covering all aspects of soil and water management shall be observed for prevention of mycotoxin contamination.

5.2 Site selection and land preparation

5.2.1 The topography of the land should be considered during site selection as it influences environmental factors like soil moisture, drainage and microclimates which in turn affects fungal growth and toxin production.

5.2.2 Farm plans and site selection activities should be drawn and done in accordance with Environmental Social and Impact Assessments (EIA) as per NEMA legislations and regulations. The farm plans should also show the areas covered by each crop.

5.2.3 The EIA or risk assessments shall take into account potential contaminants (chemical, radiological and biological), quality of water , soil health , and availability of sustainable water sources, prior use of land, and impact on the adjacent areas among other factors.

5.2.4 There shall be a correction and corrective action plan giving strategies on how to deal with identified risks in agricultural sites. The severity and probability of each identified mycotoxin contamination risk in the site shall be indicated as well as the measures to control them.

5.2.5 In crop production areas, measures shall be taken to avoid cross contamination from places demarcated for housing, washrooms, waste disposal sites, wastewater treatment points, utility stores and social facilities.

5.2.6 The records and justifications showing the suitability of the site for the agricultural activity shall be available.

5.2.7 The sites where the risk assessments have been identified non- controllable aspects that are critical to human health, animal health and the environment shall not be used for agricultural activities.

5.2.8 Soil testing shall be conducted 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.

5.2.9 Soil sanitation for mycotoxin practices that reduce fungal growth and mycotoxin contamination in soil and crops shall be observed,

5.2.10 The field shall be prepared for each new crop by ploughing 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, with conservation Agriculture, 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.

5.3 Crop rotation

5.3.1 Appropriate crop rotation/sequence schedule should be developed to avoid planting the same crop or related crops in the same field, for more than three consecutive seasons. Crop rotation will help to reduce the inoculum in the field which may originate from debris remaining after harvest that harbours toxigenic fungal spores

5.3.2 Crops found to be particularly susceptible to certain species of toxigenic fungi should be avoided in crop rotation. Some of these crops are infected after harvest and the resulting seeds can carry toxigenic fungal spores.

5.3.4 Crops of low susceptibility to toxigenic fungi such as clover, alfalfa and other legumes can be used in rotation to reduce the inocula in the field. Wheat and maize have been found to be particularly

susceptible to Fusarium species and they should not be used at very close positions in rotation with each other .

5.3.3 Some of the most susceptible crops to toxigenic fungi and the mycotoxins that can be produced are shown in Annex A ..

6 Planting

6.1 Planting should be done using certified seeds and should be as per instructions provided in/ on the package.

6.2 When available, grow varieties that are at least partially resistant to toxigenic fungi and insect pests for lower mycotoxin accumulation.

6.3 it is recommended to grow varieties suited to the agroecological areas of the country by virtue of their specific physiological and agronomic traits.

6.4 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.

6.5 Ensure appropriate plant density 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. Where the fertilizer application is required, it should be done according to the recommended application instructions.

7 Pre-harvest

7.1 . Approved pesticides shall be used to minimise insect damage and fungal infection in crops and within the vicinity of the crop. Appropriate practices within an integrated pest management programme are recommended.

7.2 Where applicable predictive weather models could be used to plan the best application timing and mode of pesticide application. Approved biological control agents should be used to manage mycotoxin contamination.

7.3 Certain weed species can act as hosts for toxigenic fungi that can increase plant stress. Due to competition of weed species during crop development, it is important to control weeds in the crop by using mechanical methods, registered herbicides or other safe and suitable weed eradication practices utilising an integrated pest management programme.

7.4 Mechanical damage to plants during cultivation, irrigation and pest management practices should be minimized.

7.5 Lodging of plants should be minimized 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.

7.6 . 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 crop stress in some growing situations. Excess precipitation during anthesis (flowering) makes conditions favourable for

dissemination and infection by fungi such as *Fusarium* spp. and *Aspergillus* spp .; thus, irrigation during anthesis and during the ripening of the crops, should be avoided.

7.7 Before harvest ensure that all equipment, to be used for harvesting, drying, cleaning, transport and storage of crops, is in good working condition and practically free from crop residues, grain and dust. A breakdown of equipment during this critical period may cause grain quality losses and enhance mycotoxin formation. Keep important spare parts available on the farm to minimise time loss from repairs.

7.8 The harvesting equipment shall be calibrated and records of calibration maintained. The equipment needed for moisture content measurements should be available and calibrated.

7.9 Sampling and testing plans for grains should be developed by competent personnel and should be done as per KS EAS 900

8. Harvest

8.1. Timely harvesting should be done and at physiological maturity. Delayed harvest of grain already infected by *Fusarium* spp and *Aspergillus* spp may cause an increase in the mycotoxin content of the crop. Models could be used to predict the mycotoxin production based on environmental conditions, such as climate conditions and agricultural production conditions, being a guide to timely monitoring and surveying of mycotoxin levels.

8.2 Proper drying techniques should be used in order to avoid contamination by contaminants such as polycyclic aromatic hydrocarbons (PAH) and dioxins generated by improper drying techniques .Where available, mechanical drying equipment may be used as an alternative to field drying in limiting mycotoxin production during the final stages of crop maturation.

8.3 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 from crop residues, old grain, grain dust, insects and visible fungal growth before use and reuse.

8.4 Steps such as avoiding large stack of the swaths and visual inspection , rouging, separation of infected plants should be taken to minimise the spread of infected seed heads, chaff, stalks, and debris (crop residues) onto the ground where spores and other fungal structures may survive and serve as inocula for future crops. Mechanised harvest methods such as the use of combines result in large amounts of the crop residue being left in the field. Mechanical damage to the grain and contact with soil during the harvesting operation should be avoided.

8.5 During harvesting operation, the moisture content should be determined in several spots as per the sampling plan (7.9) of each load of the harvested grain since the moisture content may vary considerably within the same field. As far as possible, avoid harvesting grain with high moisture content due to precipitation or morning dew or during late afternoon as it takes a longer time to dry.

8.6 Sampling and testing during preharvest monitoring or surveying of grain should be done to determine fungal infection and mycotoxin contamination levels in the field. When preharvest monitoring or surveying of grain shows a field as having a higher fungal infection rate, harvest and store grain from such field(s) separately from those fields with a lower infection rate.

8.7 Harvested grain that has not been dried to a safe storage moisture level should not be stored or transported in bins, wagons or trucks for prolonged periods of time. Transit time for movement from field to drying facility should be minimised unless the grain is already at acceptable storage moisture

levels before harvest. When necessary, it is recommended that the trucks and containers be opened, to increase aeration and minimise the condensation effects.

9 Drying and cleaning before storage

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

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

9.3 moisture levels in harvested grains shall be low enough to permit safe storage for even relatively short periods of time ranging from a few days to a few months. A maximum level of 13.5% moisture content is generally considered to be low enough to prevent further growth of preharvest toxigenic fungi and germination of spores of fungi that typically infect grain and produce mycotoxins during storage.

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

9.5 A clean liner eg. Tarpauline or drying sheets should be used to dry grains to prevent contamination.

9.6 Chemicals shall not be used to mask the actual moisture content and other grain defects during drying.

9.7 Mechanical drying is preferred. Flat bed and re-circulating batch driers are adequate for small scale operations while using a continuous flow-dryer is preferred for large scale drying prior to long storage periods.

9.8 Grains should not be excessively dried or subjected to excessively high drying temperatures in order to preserve nutritional quality and suitability for milling or other processing. The use of good drying practices is essential to avoid contaminants generated by the process. Avoid accumulating large quantities of grain in the pre-drier storage or “wet bin ”, especially when field conditions are warm.

9.9 Grains should be cooled adequately under suitable conditions to avoid moisture reabsorption and breakage while in storage.

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

9.11 Sampling and testing shall be done as per KS EAS 900 and KSEAS 901 respectively, to ascertain the moisture content and mycotoxin levels.

9.12 non-conforming consignments of grains shall be isolated and corrective action taken and documented.

10 Storage after drying and cleaning

10.1 Bins, silos, sheds and other buildings intended for grain storage should be dry, well-ventilated structures that provide protection from rain, snow, ground water, hot spots ,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 mould infection.

10.2 Storage structures shall be designed so as to minimise wide fluctuations in the temperature of the stored grain.

10.3 Storage facilities shall be cleaned and disinfested/ disinfected prior to receiving grain to remove dust, fungal spores, grain, crop residues, animal and insect excreta, insects, soil, , foreign material such as stones, metal and broken glass, and other source of contamination. Only (Pest control and Produce Board (PCPB) approved pest control products shall be used for disinfestation and disinfection.

10.4 For bagged commodities, ensure that bags are clean, dry, appropriately labelled and stacked on pallets. The bags should facilitate aeration and be made of food-grade materials that do not attract insects or rodents and are sufficiently strong to withstand storage for longer periods. The bags shall not be in contact with the floor, the wall and the roof.

10.5 The moisture content of the lot shall be determined, and if necessary, the grain shall be dried to the moisture content recommended for storage.

10.6 The appropriate level of moisture content of the grain shall be in accordance with the relevant standard. Fungal growth in grain is closely related with water activity (Aw). Although the appropriate moisture content for fungal growth on various grains is different, the maximum Aw to avoid fungal growth is basically the same. It is recognised that fungal growth is inhibited at Aw of less than 0.70..

values of moisture content in relation to different water activities at 25ºC for some cereals is shown in Annex 2 .

10.7 Ongoing monitoring of the conditions of the storage facility and stored grain is essential to ensure the grain is kept at acceptable temperature and moisture levels and substantially free of rodents, and stored product pests such as grain beetles, weevils and mites.

10.8 Significant fluctuations in grain temperature and increases in grain moisture can provide favourable conditions for mould growth and production of mycotoxins. Physical damage to grain kernels during storage caused by pests, such as rodents, weevils and moths can also contribute to increases in mould growth.

10.9 The mycotoxin level in inbound and outbound grain shall also be measured using adequate sampling and testing programs that is appropriate to the mycotoxin monitoring system.

10.10 To more effectively monitor the condition of stored grain, it is advisable to measure the temperature and humidity of the storage facilities and the stored grain at regular time intervals during storage. A grain temperature rise of 2-3°C may indicate microbial growth and/or insect infestation. If the temperature or moisture becomes unacceptably high, where possible, aerate the grain by circulation of air through the storage area to maintain proper and uniform temperature levels.

10.11 Aeration should be conducted, if possible, during periods of low ambient relative humidity of air being forced through the mass of stored grain. Aeration during periods of high relative humidity can actually increase condensation and water activity in stored grain whose temperature is below ambient

air temperature. Grain can also be recirculated or transferred from one storage container to another to promote aeration and disruption of potential hot spots during storage.

10.12 If grain spoilage or mould growth in grain is observed, separate the apparently infected portions of the grain and collect samples for mycotoxin analyses, using appropriate sampling plans. When spoiled grain is removed, it is extremely important to minimise the mixing of the spoiled grain with the remaining portion of grain that appears to be in good condition. Small quantities of highly contaminated grain can greatly increase mycotoxin levels in grain that is otherwise in good condition. After spoiled grain has been removed, it may be necessary to aerate the remaining grain to lower the temperature and the moisture to acceptable levels.

10.13 It is important to note that reduction of grain temperature below 15^{o} C that can occur during colder months grain-producing regions will contribute to safe storage and prevention of mould growth and mycotoxin production and inhibit insect growth and reproduction.

10.14 Good housekeeping practices (GHP) to minimise the levels of pests, such as rodents, insect and fungi in storage facilities should be used. This may include the use of suitable, approved pest control products by PCPB or appropriate alternative methods within an integrated pest management programme. Care should be taken to select and use only those pest control products that will not create a safety concern based on the intended end use of the grains and the maximum levels of pesticide residue dictated by regulation or buyer specifications. Since rodent pests can damage the crop during storage, the storage facility should be kept free of rodents such as rats and mice.

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

10.16 non-conforming consignments shall be isolated and corrective action taken and documented.

11 Transport from storage

11.1 Cleaning and disinfecting transport vessels and containers

11.1.1 Transport containers, vehicles such as trucks and railway cars and vessels (boats and ships) shall be inspected to ensure they are dry and free of old grain, grain dust, visible fungal growth, musty odour, insects and any contaminated material that could contribute to mycotoxin levels in lots and cargoes of grain.

11.1.2 As necessary, transport containers should be cleaned and disinfected with appropriate substances (which should not cause off odours, flavour or contaminate the grain) before use and re-use and be suitable for the intended cargo.

11.1.3 Cereals shall not be transported in the same container or vehicle with potential contaminants. At unloading, the transport container should be emptied of all cargo and cleaned as appropriate.

11.2 Moisture content and temperature fluctuation during transport

11.2 .1 Shipments of grain shall be protected from additional moisture by using covered or airtight containers or tarpaulins. Minimise temperature fluctuations and implement effective measures to prevent conditions that may cause condensation to form on the grain, which could lead to local moisture build-up and consequent fungal growth and mycotoxin production.

11.3 Pest management

11.3.1 insect, bird and rodent infestation during transportation should be avoided 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. Approved pest control products may be used.

11.3 2 Sa

cereal grains removed from storage for transport should be sampled and tested at loading or unloading for moisture content and mycotoxin levels before going into storage or grain processing facilities, especially when the risk of mycotoxin contamination is high as a consequence of unfavourable conditions during grain production and harvest.

11.3.3 non-conforming consignments shall be isolated and corrective action taken and documented.

12 Processing and cleaning after storage

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

12.2 Analytical testing can be used as a tool to monitor mycotoxin levels throughout the cereal grain supply chain. Brushing, scouring and peeling to remove hulls and bran layers of the grain can significantly reduce mycotoxin content in milling fractions derived from the endosperm (i.e. flour) as the outer parts of the kernel of most cereal grains typically contains higher mycotoxin levels or adhering contaminated dust.

12.3 Redistribution of the mycotoxins present in unprocessed grains can result in unacceptably high levels of mycotoxins in other fractions (e.g. bran) and products that contain such fractions. Where these fractions are to be used for food use rather than being discarded, it is also important to monitor mycotoxin levels to ensure food safety in the products as consumed. Caution and proper procedures should be followed when using such removed fractions as animal feed.

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

12.5 Milled grain products that are stored for long periods of time are also susceptible to mould growth and increased mycotoxin levels. Therefore, it is important to avoid storing flour and other milled grain products for long periods of time, but if it is unavoidable, then the products should be stored in proper storage containers and safe moisture levels should be maintained with minimum temperature changes. Such containers must deter insect and rodent infestation and should be subject to integrated pest control measures.

12.6 Milled grain products should be separated from whole grains during storage .

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

13 Sampling and testing

Analytical testing can be used as a tool to monitor mycotoxin levels throughout the cereal grain supply chain.

13.1 Sampling and testing shall be done in accordance with KS EAS 900 and KS EAS 901 respectively.

13.2 Validated commercially available screening tests may be used for monitoring purposes. The proper implementation and use of any such tests or tools is critical to their provision of accurate information and data.

13.-3 Personnel carrying out sampling and testing shall have the required competence to perform the tests. There should be commitment of provision of adequate resources and training so that sampling plans and test procedures can be properly performed.

14 Climate change

14.1 Due to Climate change the fungal behaviour and distribution may be altered and, increase the risk of exposure to mycotoxins.

14.2 Predictive models may be used to inform proper planning on the best time to carry out activities along the value chain.

15 Traceability

15.1 There shall be a traceability system outlining a process flow to ensure transparency, accountability and safety within the value chain.

15.2 Records of the suppliers and off-takers of the grains shall be maintained.

15.3 The traceability system shall ensure that grains that do not conform to food safety and quality requirements are identified and located for removal from the supply chain .

Annex A

(Informative Annex)

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

Crops	Fungi	Potential Mycotoxins
Maize	*A. flavus* *A.parasiticus* and other related species	Aflatoxin
	Fusarium graminearum *F. culmorum*	deoxynivalenol,nivalenol, zearalenone
	F. verticillioides *F. proliferatum*	Fumonisins
Rice (upland)	*Fusarium* spp	Aflatoxins, 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*	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
	F. poae	T-2 toxin , HT-2 Toxin
Barley	*F. graminearum* *F. culmorum* *F. asiaticum*	deoxynivalenol,nivalenol, zearalenone
	F. poae	T-2 toxin , HT-2 Toxin
	A. ochraceous. *P.verrucosum.*	Ochratoxin A
Oats	*F. graminearum* *F. culmorum* *F. langsethii* *F. poae*	deoxynivalenol, nivalenol, zearalenone, T-2 and HT-2 toxin

	A. ochraceous. *P.verrucosum.*	Ochratoxin A
Rye	*F. graminearum* *Claviceps purpurea*	deoxynivalenol, ergot alkaloids, fumonisns, ochratoxin A
Millet	*F. graminearum*	deoxynivalenol
triticale	*F. graminearum*	deoxynivalenol
Cotton seeds	A. flavus A. parasticus	Aflatoxins
Teff	*A. flavus* *A. parasticus* *Fusarium* spp *Penicillium* spp	Aflatoxins, Fumonisins, Ochratoxin A
Peanuts	*Aspergillus flavus* *A. parasiticus* *A. nomius* And other related species	Aflatoxin

Annex 2

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

Cereal	**Moisture content (%) at various water activities**			
	0.60	**0.65**	**0.70**	**0.75**
Rice	13.2	13.8	14.2	15.0
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
Millet				
Oat	11.2	12.2	13.0	14.0
Rye	12.2	12.8	13.6	14.6

Bibliography

1 Code of Practice for the Reduction of Contamination of Food with Polycyclic Aromatic Hydrocarbons (PAH) from Smoking and Direct Drying Processes (CXC 68-2009)

2 Code of Practice for the Prevention and Reduction of Dioxin and Dioxin-like PCB Contamination in Food and Feeds (CXC 62-2006)