

C O D E X A L I M E N T A R I U S

INTERNATIONAL FOOD STANDARDS



Food and Agriculture
Organization of
the United Nations



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Organization

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CODE OF PRACTICE FOR THE PREVENTION AND REDUCTION OF MYCOTOXINS IN SPICES

CXC 78-2017

Adopted in 2017.

1. INTRODUCTION

The production, processing, packaging and distribution of spices can be very complex. These processes can span long periods of time and possibly include a wide range of establishments. Dried product processing generally involves cleaning (e.g. culling, sorting to remove debris), grading, sometimes soaking, slicing, drying, and on occasion grinding/cracking. Some spices are also treated to mitigate microbial contamination. Processing and packaging/repackaging may also take place in multiple locations over long periods, since spices are prepared for different purposes.

A. Objectives

The objective of this document is to establish a general code of practice for the prevention and reduction of mycotoxins in spices in order to attain as low as reasonably achievable level of these toxins by applying specific Good Agricultural Practices (GAPs), Good Manufacturing Practices (GMPs) and Good Storage Practices (GSPs) throughout all the steps in the food chain, thus reducing consumers' exposure through preventive measures.

B. Scope, use and definitions

Scope

This Code applies to spices - whole, broken, ground or blended. Dried aromatic herbs are not included under the scope of this COP.

Use

This Code should be used in conjunction with the *Code of Hygienic Practice for Low Moisture-Foods* (CXC 75-2015) and its annex on spice and culinary herbs, and other relevant Codex codes of practice.

This Code is a recommendation to which producers, transporters, processors and manufacturers in different countries should adhere as far as possible taking into account the local conditions and difficulties in implementation of all the measures specified therein while ensuring the safety of their products in all circumstances. Flexibility in the application of certain requirements of the primary production of spices can be exercised, where necessary, provided that the product will be subjected to control measures sufficient to obtain a safe product.

Definitions

Spices: dried plants or parts of plants (roots, rhizomes, bulbs, bark, flowers, fruits, and seeds) used in foods for flavouring, colouring, and imparting aroma. The term applies equally to spices in the whole, broken, ground and blended forms, including also spices harvested as dried.

Source Plant: plant (non-dried) from which the spice is derived.

2. RECOMMENDED PRACTICES BASED ON GOOD AGRICULTURAL PRACTICES (GAP), GOOD MANUFACTURING PRACTICES (GMP) AND GOOD STORAGE PRACTICES (GSP)

2.1 Pre-harvest agricultural conditions

Spices are susceptible to contamination by toxigenic fungi in the field, during drying and storage. The use of appropriate GAP to reduce the toxigenic fungi growth and dissemination is recommended.

When appropriate, an appropriate crop rotation or sequence is recommended in order to regenerate the soil fertility and reduce the inoculum load of the relevant toxigenic fungi, to minimize the carry-over of mould from one year to the next. It is also appropriate to avoid vicinity of crops which are known to be host plants for *Aspergillus flavus*, such as maize.

Reduction of plant stress using irrigation, fertilization, pruning and pest and disease control should be implemented.

Insect damage which enhances fungal infection in the vicinity of the crop, can be minimized by proper use of registered insecticides and other appropriate practices within an integrated pest management program.

When conditions require, recommended insecticides may be necessary to minimize damage to source plants, which may later favour entry and development of toxigenic fungi; for example, through open galleries made by caterpillars.

Weeds around the crop should be controlled by use of mechanical methods or by the use of appropriate registered selective herbicides or other safe and suitable weed eradication practices. Avoiding the use of livestock manure as fertilizer can help control the proliferation of both weeds and toxigenic fungi. It may also be useful to establish an appropriate planting density to further discourage weed proliferation during plant development.

The use of recommended soil fungicides in the process of farm soil preparation may be beneficial to reduce the inoculum load of toxigenic fungi. The presence of debris in bare seed may also provide a vector for fungal infection. At sowing, use disinfected seeds to prevent mould and insects and carefully choose the planting season so that the collection of plants takes place in the driest season. This good practice is essential in areas with a warm and humid climate.

The use of fungicides is a very effective practice to prevent fungal growth. However, fungicides must be applied with special care since some of them could lead to the reduction of certain non-toxigenic fungal flora and stimulation of other toxigenic fungi growth.

It is recommended that untreated organic waste not be applied to soil as it could allow the proliferation of toxigenic fungi, human pathogens, food spoilage bacteria, and also weed seeds and other unwanted plants. This is particularly important for spices that are swathed rather than straight cut, as rain splash is more likely to contaminate swathed spices. The use of properly treated organic waste (compost) or treated sewage (or biosolids) is encouraged in order to improve soil fertility and increase competitive fungi.

Spray irrigation should be avoided during the flowering period for all the spices coming from aerial parts of the plant. This could increase both the rate of normal dispersion of spores and the chances of source plant infection with toxigenic fungi. It is recommended also to avoid flood irrigation because it could spread disease throughout the field.

Soil with good drainage must be chosen in order to avoid water logging.

It is recommended that diseased and injured plants or parts thereof be removed from the field in order to reduce the inoculum load of toxigenic fungi.

2.2 Post-harvest agricultural conditions

2.2.1 Harvest

During the harvesting operation, the moisture content should be determined in each load of the harvested commodity since it affects drying times. To the extent possible, avoid harvesting crops with high moisture content (for instance, due to precipitation or morning dew and/or during late afternoon) as it takes a longer time to dry and increase the likelihood of fungus growth and mycotoxin formation.

Mechanical damage of the plant material, a type of stress that occurs during the post-harvest manipulation of crops, which is accompanied by physiological and morphological changes that increase the possibility of subsequent fungal contamination, should be avoided.

Spices coming from aerial parts of the plant that have fallen to the ground are known to be exposed to mould growth. Crops that are affected by mould or infected should be removed. Alternatively, the source plant that has fallen to the ground can be collected separately and can be included in the main lot after it has been washed, cleaned, dried and evaluated for contamination.

When it is feasible, the soil under the plant should be covered with a clean sheet of plastic during harvest to prevent commodities from getting contaminated by dirt or mixed up with mouldy parts of the plant that have fallen prior to harvesting. It is not applicable to spice rhizomes.

Wherever possible a system for differential harvesting should be applied, so that once products are ripe they are harvested. This ensures good quality and helps prevent mould growth and mycotoxin production from overripe crops. In case of harvesting unripe crops, more time is needed to dry than ripe crops.

If possible, only the amount that can be processed in a timely manner should be picked in order to minimize growth of toxigenic moulds prior to processing.

It is important that the pre-harvest interval advised on the label of the fungicide is observed.

Wherever possible, the harvesting procedures implemented each season should be documented by making notes of measurements (e.g. temperature, moisture, and humidity) and any deviation or changes from recommended practices. This information may be very useful for explaining the cause(s) of fungal growth and mycotoxin formation during a particular crop year and may help to avoid similar mistakes in the future.

2.2.2 Drying on the farm

The main purpose of the drying operation is to efficiently decrease the high water content of the just harvested spices to a safe level in order to get a stable, safe and good quality product. Drying of crops should begin immediately after harvest and farmers should not hold the crop in piles or in bags for long period of time. When necessary, plastic sheets should be used to cover the crop in the event of rain during the drying process. The drying yard should be located away from contaminant sources such as dusty areas and should receive maximum sun exposure and air circulation, during most of the day, to speed up the drying of the spices. Shady and low areas should be avoided.

The surface for the drying yard should be chosen according to the climate of the region, cost and quality of the dried product, as any type of surface has advantages and disadvantages. Bare soil is not appropriate for rainy areas. Plastic canvas gets humid under the spice layer, promoting fungal growth. In rainy or wet regions spices must be covered and re-spread, once the surface has dried.

The pace and total time of the harvest should be based on the available area of the drying yard and the average time necessary for drying, considering both good and bad weather.

The following practical measures should be incorporated into the drying process;

- (a) Dry spices only in thin layers, 3 to 5 cm in depth. In some cases (e.g. low air humidity, good air circulation and sun intensity, or in usually dry regions), thicker layers can be used.
- (b) Turn over the spice layer constantly during the daytime to allow faster drying, to reduce the risk of fungi growing and help to produce a better quality product.
- (c) Allow for the appropriate ventilation of the wet spice during the night in order to avoid condensation.
- (d) Do not mix different types of spices nor spices from different days of harvest. Use a specific identification for each one of them to identify each type of spice and day of harvest.
- (e) Protect the drying yard area from animals, which can be a source of biological contamination for the drying spice.
- (f) In order to avoid insect damage during drying, check for the presence of insects and if necessary use integrated pest management in drying yard for the control thereof.
- (g) Monitor the drying process regularly. Start taking samples from different points of each lot, two or three days before it is expected to be fully dry and continue re-evaluating it daily until it reaches the desired moisture content. Instrumental measurements should be adopted at field level.
- (h) Avoid rewetting the spices because it favours rapid fungal growth and the possibility of aflatoxin and OTA production.

Provide a clear and practical training for drying yard workers, including adequate use of moisture measuring equipment.

Repair, clean, protect and keep equipment in a clean storage area until the next season. Moisture measuring equipment should be regularly cross checked and calibrated once a year before harvest

In the sun drying process, the product is spread on surfaces such as cement or brick terraces, tarpaulin, plastic canvas, bamboo and sisal mats, raised tables covered in wire mesh or fish farm netting (paragraphs 49 and 55.1a also apply on the farm).

The drying process can be divided into three stages. In each stage, aflatoxin and OTA producing fungi will have varying opportunities for growth:

- (a) At the first stage, there is a slight decrease in moisture content. The high moisture content ($a_w > 0.95$) provides unsuitable conditions for aflatoxin and OTA producing fungi to grow. However, other microorganisms, such as other hydrophilic fungi (yeasts and moulds) and bacteria, may spoil the product if it is kept too long at $a_w > 0.95$ after harvest.
- (b) The second stage is the one of maximum loss in moisture content. During this stage (a_w lower than 0.95 but higher than 0.80), there are favourable conditions for aflatoxin and OTA producing fungi to grow and therefore it is necessary to implement precautionary measures as recommended in paragraphs 28 to 33.
- (c) The third stage which starts at $a_w 0.80$, is much drier compared to the previous two stages. There is a slower slight decrease in the remaining moisture content. Conditions at this stage do not favour the growth of aflatoxin and OTA producing fungi.

Therefore the most important point is to control the period of time in which the spices remain in the drying yard, in the range of water activity where aflatoxin and OTA-producing fungi can grow ($a_w 0.8-0.95$). Five days or less in the drying yard is enough and effective to prevent aflatoxin and OTA accumulation. In general, a maximum a_w of 0.65 is sufficient for protecting spices from damage by fungi.

2.2.3 Transport

Containers and transportation devices (e.g. wagons, trucks) to be used for collecting and transporting the harvested commodity from the field to drying and storage facilities after drying, should be clean, dry and free of crop residues, old plants, plant dust, insects and visible fungal growth before use and re-use.

Harvested commodities that have not been dried to a safe storage moisture level at farm level should not be stored, but shall be transported to a processing plant to be dried without delay. When necessary, it is recommended that the trucks and containers should allow appropriate aeration and minimize the condensation effects, under conditions protected from rain (e.g. lateral openings).

2.2.4 Storage (source plant)

Fresh material for spices or source plants should be processed as quickly as possible. Avoid storage of source plants as any period of storage (in a bag or in a pile) increases the likelihood of mould growth. Wherever possible, start drying on the day of harvesting. Source plants should be packed in bags made of porous material such as jute bags or woven plastic bags. Avoid non-porous plastic bags for packing of dried products.

Gunny bags should be stored off the floor (on pallets) and away from the walls (at least 30 cm) so that any potential condensation does not cause the product to become wet and to avoid the chance of moisture entering through the wall. Internal walls, floor surfaces, the junctions of the floor with the walls and the junctions between two walls should be made with a smooth, water-proof, non-absorbent, washable and non-toxic material.

Control of insect and rodent activity and maintenance of appropriate moisture levels and temperature in the storage room is essential. Insects and rodents can spread contamination and spoil the crop.

Storage facilities should include dry, well-vented structures that provide protection from rain, drainage of surface water, protection from entry of rodents and birds, and minimum temperature fluctuations.

The storage facilities should be cleaned and disinfected with appropriate substances (which should not cause off-odours, flavours or contaminate the crop). The use of registered fumigants or insecticides within the permissible level may be useful.

Store fresh material for spices or source plants in suitable storage temperature, for example, 5 to 8 degrees Celsius. Care must be taken in cold storage to prevent condensation from the chiller units falling onto the product.

Relative humidity of storage conditions should be controlled as appropriate, for example, less than 75% for lower water activity of source plant.

2.3 Industrial processing conditions

2.3.1 Sorting

It is necessary to separate the raw material upon receipt, to prevent any cross-contamination during the cleaning, washing, and processing stages.

Raw materials should be inspected and sorted prior to introduction into the processing line. The inspection may include visual inspection and removal of foreign material, the absence of any musty odours and analytical tests for mycotoxin contamination.

When necessary, prior to drying, the harvested products should be sorted to remove any visible organic debris or mouldy products before washing with potable water. Prior to washing, there should be a selection process to eliminate any fresh source plant showing symptoms of fungal infection, and small portions of any contaminated part should be removed, because they can contaminate a whole batch. This procedure can be carried out on the farm. The discarded materials should be properly disposed of in order to avoid the recontamination of the clean material. If washing is not needed it should not be carried out as washing might spread the contamination of certain hot spots to the rest of the harvest.

2.3.2 Processing

The time between harvesting and drying should be as short as possible, including transport from the field to post-harvest facilities. Drying should be done on a concrete surface, preferably a raised platform. Whenever possible, avoid drying on plastic sheets or tarpaulins as the moisture remains in contact with the source plants during the drying process. In case those plastic sheets or tarpaulins are used, extra care should be taken for homogeneous drying by shifting the spices at regular intervals.

Proper storage is necessary to prevent biological activity through adequate drying to an appropriate moisture level for the spice. The raw material for spices may need to be covered with plastic sheets at night to avoid having dew come in contact with the raw material. Care must be given to minimize moisture condensation. Growth of mould prior to, during and after drying may result in mycotoxin production. Inappropriate handling of raw materials may support the growth of several spoilage and toxigenic moulds prior to drying. Proper drying of spices to achieve a water activity below 0.65 is adequate to prevent mycotoxin production. Below a water activity of 0.65, there is hardly any mould growth.

The drying area should be elevated to prevent pest ingress and potential flooding, and should be constructed of a material that can easily be cleaned and that will not contaminate the stored spices.

A concrete pad can serve this purpose and in this case it should have a slightly sloping surface to allow water runoff from the product and may require a perimeter fence to prevent farm animals, pets, pests, etc. from accessing the source plant or raw material for spices as it is drying.

It is important to ensure that the drying yard is cleaned prior to use.

Drying of source plants may be performed mechanically (for rapid drying) or naturally (e.g. slower drying under the sun for several days). Both processes are detailed in the *Code of Hygienic Practice for Low-Moisture Foods* (CXC 75-2015), Annex III, Annex on Spices and Dried Aromatic Herbs. For instance, mechanical drying is recommended for plant sources such as nutmeg as the harvest occurs during the rainy season.

Drying methods:

1. Sun drying

- (a) Drying should not occur directly on the ground. Use trays, bamboo mats or drying yards, and make sure that these are clean as it is known that mould spores from previous use could re-contaminate product during drying. Techniques for cleaning all of the above should be taught to farmers. Never use unhygienic materials (such as cow dung paste) in bamboo mats to fill the holes.
- (b) The availability of additional tarpaulins should be ensured to cover the source plant (raw material) in case of any unexpected rain. When using tarpaulins, care should be taken that condensation of water is prevented, e.g. by keeping lateral holes to increase ventilation.
- (c) Drying areas should be raised from the ground to prevent water or pests from entering. Sun drying by using trays put on racks at a sufficient distance from soil may be applied. This practice allows air circulation to accelerate the drying.
- (d) Pathways should be made in the drying area to prevent walking on the source plant, as this can damage the source plants and leads to mould growth.
- (e) The layer of drying spices should not be more than 4 cm thick, the drying raw material must be regularly raked (5-10 times per day) and should be protected during drying from rain, night dew and any other sources of moisture. Raw materials that have been dried should not be allowed to get wet again during storage or at any other time.

2. Controlled drying

- (a) A controlled drying system can be employed to give better quality, reduce fungal contamination and ensure less risk of mycotoxin production.
- (b) Solar drying is one method, where raw materials are protected in polythene tunnels and the temperature is controlled through the use of air circulation. Such tunnels should be designed so that the risk of condensation on the crop is eliminated.
- (c) Hot air drying can also be employed and care should be taken to ensure that there is no risk of fumes from the fuel coming into contact with the product. This can be best achieved through the use of a heat exchanger so that only clean air comes into contact with the product.
- (d) A solar heat exchanger can also be used where hot air is generated from the sun's rays.
- (e) The recommended optimum drying temperature is 50-60 Celsius degrees and relative humidity in the drying chamber should be reduced for the spice to achieve a safe moisture level (12-14% has been shown to be safe in most cases).

3. Smoke drying

- (a) Refer to the *Code of Practice for the Reduction of Contamination of Food with Polycyclic Aromatic Hydrocarbons (PAH) from Smoking and Direct Drying Processes* (CXC 68-2009). This type of controlled drying must be carried out in drying houses. Drying houses have a variable size, but the structure is either rounded or squared, around five meters high. The material used to build the drying house is terracotta or bricks. The smoke is produced with wood and the temperature must be under control.
- (b) This system is conducive to slow, gentle, non-aggressive drying so that within 10 to 15 days the water content of the fruit falls from 80% to under 15%. The final product obtained has a smoky taste and aroma and a very stable colour.

Before grinding the source plant, a cleaning step can be applied as an optional choice.

Sterilization processes are effective in reducing the mould load in spices. These mould-reducing processes should be considered once the spice is dry (final processing). There is at least one process authorized for reduction of fungal growth in spices (irradiation) in some countries/regions. Irradiation should be applied in accordance with the *General Standard for Irradiated Foods* (CXS 106-1983) and the *Code of Practice for Radiation Processing of Food* (CXC 19-1979). It should not be used as a substitute for good hygienic and good manufacturing practices or good agricultural practices. It has been proven to be efficient in eliminating fungi in chilli, coriander, cumin, turmeric and Ashanti pepper. Moreover, other treatments, such as UV, can be utilized to reduce or eliminate toxigenic fungal spores in spices. However, these treatments do not reduce the level of mycotoxins formed earlier in the chain.

2.3.3 Storage after Drying and Cleaning

Fungal growth on stored spices is mainly influenced by temperature and relative humidity of the storage facility and the moisture content of the spice. Storage condition should best keep the spices at a_w of <0.65.

Temperature levels within large warehouses can be ideal for mould growth, particularly towards the roof, thus suitable ventilation should be provided in order to ensure proper management/control of both temperature and humidity.

It is recommended that local ventilation systems be employed to produce currents of cold, dry air to assure good ventilation. Storage in a clean, dry place; protected from dust, debris, insects, rodents, other animals and birds, and away from areas of excessive human or equipment traffic is also recommended. Product should be stored in well maintained warehouses that do not allow the ingress of water through open windows, gaps beneath doors, or leaks in the storage enclosure.

Spices should not be stored with other food commodities (such as fruits, vegetables, fish) or non-food products (such as kerosene, lubricating oils) that may affect the moisture content leading to the growth of toxigenic fungi or alter the flavour or colour of the spice and provoking the unacceptable contamination of the spice with these non-food products

It is also important to ensure that product is stored off the floor and away from the walls so that any potential condensation does not cause the product to become wet. In addition, there should be good air circulation through the warehouse to prevent condensation and mould growth.

To the extent possible, storage locations should prevent access by rodents or other animals and birds and should be isolated from areas of excessive human or equipment traffic.

Practices should be in place to minimize insect infestation in the spices at all stages of production, particularly during storage. Increased insect populations raise both the temperature and moisture content of the spices allowing for the subsequent growth of moulds and production of mycotoxins. The movement of insects through the spices can facilitate the distribution of the moulds and mycotoxins throughout the product.

The effectiveness of chemical compounds used to prevent fungal growth and mycotoxin production has to be demonstrated. Treatments with approved chemicals including sodium bisulfite, ozone, or acids and bases represent an opportunity to control fungal growth and mycotoxin biosynthesis in stored spices. The use of bases such as ammonia that can affect the aroma of spices is not recommended.

The storage procedures implemented each season should be documented by making notes of measurements (e.g. temperature, moisture, and humidity) and any deviation or changes from recommended practices. This information may be very useful for explaining the cause(s) of fungal growth and mycotoxin formation during a particular crop year and may help to avoid similar conditions in the future.

2.3.4 Transport from Storage

It is important that the operator select reliable transport service-providers that adopt this code of practice and ensure appropriate transport conditions.

2.3.4.1 Preventing moisture accumulation

When the commodity is moved into or out of the warehouse, ensure that it is protected from the rain.

During transportation, attention should be given to avoid re-entry of water/moisture into the commodity and to ensure that pests or debris cannot penetrate into the commodity.

Regular checks should be made to ensure that the truck is covered and that there are no rips in the covers and no leaks on the undersides of trucks which could allow water from the road to get into the truck. Check from the inside by closing all doors and looking for holes where daylight is visible.

Trucks must be clean, dry and odour-free which helps to prevent cross contamination from previously transported products.

The pallets or wooden floors of transport containers should be dry. For products that require a long period of transportation, temperature and humidity should be monitored, where appropriate. Spices absorb moisture quickly if the bags get wet and as a result the moisture content increases considerably.

2.3.4.2 Hygiene practices during transportation

Refer to the *Code of Hygienic Practice for Low-Moisture Foods* (CXC 75-2015), Annex III on Spices and Dried Aromatic Herbs.

Bags should preferably be placed on a layer of pallets to avoid contact with the floor where condensation from the ceiling and walls may gather. If available, fully ventilated containers are preferable for spices in bags, especially if shipped from a high humidity region.

Desiccant boxes filled with calcium chloride can absorb around 100% of their own weight in moisture and may be used for added protection.

It is important that care is taken not to damage these dry-bags and any spillages should be cleaned up immediately.

It is important to maintain ample space between bags and the roof of the containers or transportation devices. Use of the saddle stow method, which minimizes side contact and maximizes airflow between the bags, is recommended.

2.3.5 *Packaging*

Because dried spices are hygroscopic, they must be packaged quickly after processing using a material that serves as a barrier to moisture. The use of packaging technologies that prevent the inflow of moisture, such as vacuum or modified atmosphere, with the use of the appropriate packaging material is an option of use.

Use of appropriate packaging can help to prevent insect contact with the commodity and therefore, limits mould growth. Packaged commodities should be kept free of moisture or humidity.

Packaging activities can occur in the growing/harvest area. Such packing operations should include the same sanitary practices, where practical, as packing spices in establishments or should be modified as needed to minimize risks. To prevent germination and growth of fungal spores, the products must be dried to a safe moisture level prior to packing.

New bags should be used when packing spices in the growing/harvest area for transport, storage, or for further sale, to prevent the potential for microbial, physical and chemical contamination.

Containers should be inspected immediately before use to ensure that they are in a satisfactory condition, as defined by the manufacturer, and where necessary, cleaned and/or disinfected; when washed, they should be well drained and dried before filling.

Removal of discarded plant material should be done on a regular basis in order to avoid accumulation that could promote the presence of pests.

2.3.6 *Product information and consumer awareness*

The manufacturer should comply with the provisions set up in the *General Standard for the Labelling of Prepackaged Foods* (CXS 1-1985) when indicating the best-before date and specific storage instructions for the commodity. This date will be justified by completing appropriate studies that take into account the characteristics of the packaging, examining unfavourable conditions that may promote mould growth and verifying the quality of the final product in order to give assurance that no mycotoxin contamination will occur until the end of the shelf-life indicated for consumption of that commodity.

Consideration should be given to provide consumer information on following storage instructions to maintain the product in a cool, dry, well-ventilated area away from heat sources such as ovens and areas with high humidity and avoid storing in a refrigerator to prevent condensation, etc. This consumer information may include tips for good use to avoid mould growth by avoiding contact with wet utensils and wooden spoons, closing containers tightly immediately after use, avoiding unnecessary stockpiling and checking the best-before date.