CODEX ALIMENTARIUS COMMISSION E

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World Health Organization

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DISCUSSION PAPER ON FEASIBILITY TO DEVELOP A CODE OF PRACTICE FOR THE PREVENTION AND REDUCTION OF MYCOTOXIN CONTAMINATION IN SPICES

(Prepared by electronic Working Group led by Spain and co-chaired by The Netherlands)

BACKGROUND

1. The Eighth session of the Committee on Contaminants in Foods (April 2014) agreed to establish an electronic Working Group led by Spain and co-chaired by The Netherlands to develop a Discussion Paper on the feasibility for a code of practice for mycotoxins in spices with specific annexes that would provide useful information for further discussion on this issue at the 9th Session of the Committee[1].

2. The electronic working group (EWG) was established and a list of participants is included in Annex 4. A discussion paper was prepared following the CCCF directions for its content. The discussion paper is provided in Annex 1. A proposed draft Code of Practice for the prevention and reduction of mycotoxins in spices is included in Annex 2. Should the Committee decides on new work on a COP, a project document is presented for consideration in Annex 3.

3. The work plan of the EWG was:

   a. To identify which mycotoxins occur in spices;

   b. To identify risk factors for mycotoxin formation in spices;

   c. To collect information on management practices in spices: Agricultural measures, prevention measures during storage and measures at processing stage and cooking stage, including existing Codes of Practices (COP);

   d. To determine which risk management measures could provide the basis of the preliminary development of a COP;

   e. To determine a possible structure for a COP and to attach a proposed draft COP for consideration by the 9th session of the Committee.

4. The working group came to the following conclusions:

   a) The aim of this draft Code of Hygienic Practice is to address specific Good Agricultural Practices (GAPs), Good Manufacturing Practices (GMPs) and Good Storage Practices (GSPs) that would help minimize mycotoxin contamination throughout all stages of the production of spices and dried aromatic herbs from primary production to consumer use.

[1] REP 14/CF paragraph 140

b) The main mycotoxins identified in spices are ochratoxin A (OTA) and aflatoxins (AFT). Many other mycotoxins, such as citrinin, sterimatocystin, zearalenone or T-2 toxins, have also been reported in spices and they seem to co-occur with the former ones. However, the latter mycotoxins have not been widely observed so far. Therefore, the EWG concluded that the proposed COP should as a starting point focus mainly on OTA and AFT.

c) Several risk factors for mycotoxin formation in spices have been identified in the literature and have been compiled in point 3 of the Discussion Paper.

d) The EWG has collected information on management practices in spices, including the existing Codex Codes of Practices, which have been compiled in point 4 of the Discussion Paper. This information is based on key documents at the international level and new scientific evidence.

e) The EWG has concluded that all the existing risk management measures compiled in the Discussion Paper could provide the basis of the preliminary development of a COP on mycotoxins in spices in general. Even though research has been carried out on risk management measures on a variety of spices, the evidence is not sufficient for extending these general management practices to each and every spice.

f) The EWG has determined a possible general structure for a COP based on similar documents in other areas and it is available in point 5 of the Discussion Paper. It is proposed to be divided into two parts, main body and annexes:

    i. Regarding the Main Body of the COP, the EWG agrees on the structure proposed in point 5 of the Discussion Paper.

    ii. Regarding the Annexes of the COP, the EWG proposes to develop specific Annexes classified by “mycotoxin” in “group of spices”.

Recommendations:

5. The working group recommends to CCCF to work on the development of a COP for the prevention of mycotoxin contamination in spices since it is feasible at this time with the information available worldwide.

6. In case the CCCF considers that work should be started at this point, the EWG makes several recommendations to CCCF:

    a. To take into account the outcome of the discussions of other EWGs within the CCCF (prioritization of the work for MLs of mycotoxins in spices, revision of the COP on mycotoxins in cereals) and other Codex Committees (recently amended Code of Hygienic Practice for Spices and Dried Aromatic Herbs in CCFH, grouping of spices in CCSCH).

    b. To agree on the general structure proposed by the EWG to be followed to draft the proposed COP on mycotoxins in spices.

    c. To make the proposal to CCFH that, for the sake of consistency and to avoid repetition, the preventive measures for mycotoxin-producing fungi included in the Code of Hygienic Practice for Spices and Dried Aromatic Herbs be moved to the COP for prevention and reduction of mycotoxins in spices.

7. Codex members and observers are invited to consider the conclusions and recommendations as indicated above with a view to advising the Committee on how to proceed further with this matter taking into account the considerations provided in Annex 1. The proposed Code of Practice as described in Annex 2 is not subject to comments but constitutes a preliminary outline on how such document can be developed. However, general comments that could enhance the overall content of the proposed COP could be provided to the Committee when considering this item. Codex Members and Observers in support of the development of the COP are invited to consider the project document as contained in Annex 3 so that proper justification for new work can be provided within the framework of the Critical Review carried out by the Executive Committee.

ANNEX 1: DISCUSSION PAPER ON THE FEASIBILITY OF A CODE OF PRACTICE FOR PREVENTION AND REDUCTION OF MYCOTOXINS IN SPICES

1 INTRODUCTION

Mycotoxins are fungal secondary metabolites that have been associated with severe toxic effects to vertebrates. They are produced by many important phytopathogenic and food spoilage fungi including *Aspergillus, Penicillium, Fusarium*, and *Alternaria* species. The contamination of foods and animal feeds with mycotoxins is a worldwide problem.

Human exposure to mycotoxins can be high due to the fact that they are present in a wide variety of foodstuffs, such as spices, cereals, oilseeds, some fruits and vegetables, nuts, coffee, wine, etc. Mycotoxins are stable compounds and therefore they cannot be eliminated from those foodstuffs. Thus, it is important to maintain the contamination of mycotoxins in food at the lowest achievable level (ALARA principle).

The control of the mycotoxins production on foodstuffs is complex as it depends on the prevailing natural environmental conditions at the pre- and postharvest stages. Further the reliable sampling for analysis is complicated by the heterogeneous distribution and, at times, low level of contamination.

For all these reasons, the most efficient way to approach the problem of mycotoxins contamination in foodstuffs is prevention or minimizing their concentrations by means of following a code of good practice.

1.1 Toxicology/toxicity of mycotoxins

Mycotoxins that have been associated with severe toxic effects to vertebrates include aflatoxins and ochratoxin A (OTA).

Aflatoxins, produced most commonly by *Aspergillus flavus* and *A. parasiticus, A. nomius* and related species, are considered genotoxic carcinogens that induce tumors in the liver of animals and humans. Aflatoxin B1 is the most common and potent carcinogen of the aflatoxins. Most of the toxicological data available are related to aflatoxin B1 (FAO/WHO, 2007). There is no toxicological reference value established for aflatoxins, but the MOE approach applies when it comes to risk assessment (FAO/WHO, 2005). Aflatoxins have been classified by the IARC as carcinogenic to humans (Group 1) (IARC, 2012). The hazard assessment approach used by JECFA for chemical contaminants (PTWI or PTDI) does not apply for toxins where carcinogenicity is the basis for concern as is the case with the aflatoxins. Instead it recommends that the level of the contaminant in food should be reduced so as to be As Low As Reasonably Achievable (ALARA). The ALARA level, which may be viewed as the irreducible level for a contaminant, is defined as the concentration of a substance that cannot be eliminated from a food without involving the discard of that food altogether or without severely compromising the availability of major food supplies (FAO, 2004). This covers the case of the JECFA evaluations of the aflatoxins made in 1987 and 1997.

Ochratoxin A, produced primarily by *Aspergillus ochraceus* and *A. carbonarius* in products of tropical and subtropical climates and *Penicillium verrucosum* in temperate climates (Pitt, 1994). *A. ochraceus* had been confirmed to produce OTA in spicesand to cause enterititis, teratogenesis and carcinogenesis in the kidney and mild liver damage (Ringot *et al.*, 2006). IARC classified OTA as a possible human carcinogen (Group 2B) (IARC, 1993). In the case of OTA, as well as for aflatoxins, the approach followed by JECFA for the risk assessment is the ALARA principle (FAO, 2004).

For OTA, JECFA has established a Provisional Tolerable Weekly Intake (PTWI) of 112 ng/Kg body weight based on deterioration of renal function in pigs (FAO/WHO, 2007).

1.2 Regulation of mycotoxins in spices

It should be noted that the other electronic working group on prioritization of the work on mycotoxins in spices for the ninth session of the CCCF will provide an overview of regulations on mycotoxins in spices.

Information about regulatory levels is available but out-dated:

http://ec.europa.eu/food/food/chemicalsafety/contaminants/legisl_en.htm

(2003) http://www.fao.org/docrep/007/y5499e/y5499e00.htm

(2012) http://services.leatherheadfood.com/eman/FactSheet.aspx?ID=79

1.3 Definition of spices

Codex definition for spices (CAC, 1995):

Spices and Dried Aromatic Plants: "The term spices, which includes dried aromatic plants, relates to natural dried components or mixtures thereof, used in foods for flavouring, seasoning and imparting aroma. The term applies equally to spices in the whole, broken or ground form".

Spices and dried aromatic herbs may include many parts of the plant, such as aril, bark, berries, buds, bulbs, leaves, rhizomes, roots, seeds, stigmas, pods, resins, fruits, or plant tops (CCFH, 2013).

Spice Blends: "Spice blends are obtained by mixing and grinding, cleaned, dried and sound selected spices."

1.4 Classification of spices

There are several lists of spices available worldwide, such as the ASTA list (33 spices) (ASTA, 2011), the ESA list (40 spices) (ESA, 2014).

There is currently an EWG on grouping of spices and culinary herbs in the CCSCH (paragraph 39 of the Report of the First Session of the Committee) (CCSCH, 2014) and the classification or grouping of spices and culinary herbs approved within that Codex Committee will be useful to the work on the COP.

2 OCCURRENCE OF MYCOTOXINS IN SPICES

In this section the occurrence of mycotoxins in spices is briefly discussed. It should be noted that the other electronic working group on the prioritization of the work on mycotoxins in spices for the ninth Session of the CCCF will provide a prioritization of mycotoxins of concern in spices.

Most spices are grown in tropical climates which are wet and humid, thereby producing difficulties with crop management. Drying the crop efficiently is critical to quality and safety to prevent mould growth and possible mycotoxin contamination (Matthews and Jack, 2011). Mandeel (2005) found *Aspergillus flavus* and *Penicillium verrucosum* among a number of other Aspergillus and Penicillium species on various spices. *P. verrucosum* was determined in cardamom, black pepper, dry ginger, fennel, coriander, caraway, and cumin.

Mycotoxins are common in spice crops such as capsicums, pepper, ground ginger and nutmeg (Matthews and Jack, 2011).

Mycotoxins identified in spices are ochratoxin A (OTA) and aflatoxins (AFT) (Hernandez Hierro *et al.*, 2008; Ramesh and Jayagoudar, 2014) and citrinin (Aquino *et al.*, 2005; Soriano del Castillo, 2007; Pfohl-Leszkowicz *et al.*, 2008; EFSA, 2012; Hackbart *et al.*, 2012; Sansing *et al.*, 2013). Several studies have identified OTA and AFT as the main mycotoxins of concern (FAO/WHO, 1998; DGSANCO, 2002; Elshafie *et al.*, 2002; Erdogan, 2004; Fakezas *et al.*, 2005; EFSA, 2006; Bokhari, 2007; FAO/WHO, 2007; FAO/WHO, 2008; Hernandez Hierro *et al.*, 2008; IOSTA, 2008; Hashem and Alamri, 2010; Jalili *et al.*, 2010; Set and Erkmen, 2010; Zaied *et al.*, 2010; IARC, 2012; Ramesh and Jayagoudar, 2014). In fact, many surveys on aflatoxins have found levels up to 28.5 ± 26.4 µg/kg (Ghali *et al.*, 2008).

Both mycotoxins, OTA and aflatoxins, are considered to be of world-wide importance by FAO (FAO, 2001). Therefore these mycotoxins are discussed in more detail below.

The main toxigenic fungi,the toxins produced and toxicity are given in the following table:

FUNGAL SPECIES	MYCOTOXINS PRODUCED	TOXICITY
Aspergillus parasiticus ***A. nomius***	Aflatoxins B1, B2, G1, G2	Carcinogenicity, hepatotoxicity (B_1>G_1>B_2>G_2)
Aspergillus flavus	Aflatoxins B1, B2	
Aspergillus ochraceus ***A. westerdijkiae*** ***A. steynii*** ***A. ochraceus*** ***Penicillium verrucosum*** ***P. viridicatum***	Ochratoxin A	Carcinogenicity, nephropathy, immunotoxicity and teratogenicity

Source: (FAO/WHO, 1998; FAO, 2001; Peter, 2006; FAO/WHO, 2008; Pitt and Hocking, 2009; IARC, 2012)

The aflatoxins-producing moulds occur widely in sub-tropical and tropical climates, throughout the world. Aflatoxins may be produced, both before and after harvest, on many foods and feeds especially oilseeds, edible nuts and cereal grain (FAO, 2001). Because of the importance of aflatoxins, *A. flavus* has become the most widely reported food borne fungus and is especially abundant in the tropics. *A. flavus* is uncommon in cool temperate climates, except in foods and feeds imported from tropical countries. The major hosts of *A. flavus* among food and feed commodities are maize, peanuts, tree nuts, cottonseed and various spices (EFSA, 2006; EFSA, 2010; IARC, 2012). The food-related hosts of *A. parasiticus* are similar to those of *A. flavus*, except that *A. parasiticus* is very uncommon in maize (IARC, 2012). The species *Aspergillus* and *Penicillium* have been classified as “storage fungi” (Atanda *et al.*, 2013). *A. flavus* in particular is characterized as an opportunistic crop pathogen as it can infect the seed and produce aflatoxins before and after harvest (Klich, 2007).

As regards OTA-producing moulds, they have been isolated from a wide range of food products, but are more common in cereal grains, grapes and raisins, coffee beans, cocoa nibs, fig, soya, dried beans, and dried ginger root (Iha and Trucksess, 2010). However, there is no agreement on the fact that these species are or are not a common cause of food spoilage, therefore if their presence could be or not a good indicator of significant mycotoxin production. For example, *A. carbonarius* is able to grow and produce OTA in grapes, *A. ochraceus* and *A. westerdijkiae* can grow and produce OTA in coffee beans (Lund and Frisvad, 2003).. Their presence or absence in any sample is probably related to length of storage rather than to geographical location or other factors (FAO/WHO, 2007; FAO/WHO, 2008), but this is not clear either, since OTA can be produced in grapes in vineyards (Leong *et al.*, 2004) and the source of ochratoxin A in Brazilian coffee and its formation has been related to processing methods (Taniwaki *et al.*, 2003).

3 RISK FACTORS FOR MYCOTOXIN FORMATION IN SPICES.

Mycotoxins can be formed at several points within the supply chain (pre-harvest, harvest, post-harvest, storage and transportation). Aflatoxin contamination can develop both in the pre- and post-harvest periods, but the highest levels are usually associated with post-harvest spoilage of food commodities. On the other hand, OTA does not usually invade the crop in the field, but mainly does it in the post-harvest phase. T

he production, processing, and packing of spices and dried aromatic herbs is very complex. The distribution and processing chain for spices and dried aromatic herbs is also highly complex and can span long periods of time and 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 and dried aromatic herbs are also treated to mitigate microbial contamination. Processing and packing/repacking may also take place in multiple locations over long periods of time, since spices and dried aromatic herbs are prepared for different purposes (CCFH, 2013).

3.1 Pre-harvest agricultural conditions

Significant levels of mycotoxins can occur in the food crops in the fields due to toxigenic fungal infection and growth.

3.1.1 Rotation

The lack of rotation may increase the inoculum load of the relevant mycotoxigenic fungi by provoking the carry-over of moulds from one year to the next.

3.1.2 Residue

Crop residue left on the soil surface after harvest is a major source of mycotoxin producing fungi infestation and the greater the amount of the crop residue in the previous year, the higher the risk of the soil infestation the following year.

3.1.3 Variety choice

There are varieties of crops which are more sensitive to the growth of certain mycotoxin-producing moulds.

3.1.4 Weeds and insects

Weeds and insects may cause damage to fruits thereby favouring entry and development of mycotoxigenic fungi.

3.2 Post-harvest agricultural conditions

3.2.1 Harvest

Mechanical damage of fruits during harvesting may cause contamination with moulds. Wet weather during harvest can also favour mould growth. Fallen fruits and leaves provide a favourablegrowing substrate for moulds.

3.2.2 Drying

Growth of mould prior, during and after drying may result in mycotoxin production. Inapropriate 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 0.60 is adequate to prevent mycotoxin production (Muggeridge and Clay, 2001; ICMSF, 2011)

3.2.3 Storage

The species of *Aspergillus* have been classified as “storage fungi” (Atanda *et al.*, 2013) but can also be present on the field. Storage environmental conditions greatly affect fungi and the associated mycotoxins (Jinyi *et al.*, 2014). Fungal growth on stored spices is mainly influenced by temperature and relative humidity (Ramesh and Jayagoudar, 2013).

Aflatoxins producing fungi growth and mycotoxin production essentially starts at a moisture content of about 16 percent (0.82 aw, equilibrium with 85% relative humidity), and at temperatures of 10 to 48°C with optimum growth at 30-33°C (Jacobsen *et al.*, 2007). It has been shown to grow down to a minimum of 0.82 water activity at 25°C, 0.81 at 30°C and 0.80 at 37°C (Pitt & Hocking, 2009). *A. flavus* grows slowly below 13°C, and most rapidly at 37°C, and does not produce aflatoxins at temperatures below 13°C or above 42°C (Coppock and Jacobsen, 2009). Aflatoxin production occurs at a temperature higher than the minimum and lower than maximum for growth. Because of effects of insect on distribution of moulds throughout the products, insect infestation should be minimized during the storage.

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 mycotoxins. The movement of insects through the spices facilitates the distribution of the moulds and mycotoxins throughout the product. The correlation of insects and mycotoxin contents has been studied in a wide variety of grains and nuts (Rajendran, 2005; Magan, 2007; Chulze, 2010)

3.3 Industrial processing conditions

3.3.1 Sorting

Damaged fruits or contaminated foreign matter can contaminate the rest of the fruits.

3.3.2 Processing

Mycotoxins are stable compounds and processing procedures have varying effects on their presence in foodstuffs depending on the type and duration of the processing procedure. Some processing methods are more effective than others..

3.3.3 Packaging

Potential microbial, physical and chemical contamination of the spices can occur if they are not packed in an appropriate manner.

3.3.4 Labeling and distribution

If appropriate storage conditions are not respected by consumers, there is no guarantee of avoidance of micotoxigenic moulds growth.

4 MANAGEMENT PRACTICES FOR MYCOTOXINS IN SPICES

There are predictive models for fungal spoilage prevention as a function of the abiotic factors (Pardo *et al.*, 2006). This can help to identify the critical control points in their production, storage and distribution processes.

The principal fungi that produce ochratoxin A in foods (among them, *Aspergillus weterdijkiae* and *A. steynii*, formerly included in *A. ochraceus*) are not associated with plants and hence are not usually present in food crops before harvest. The control of ochratoxin A in foods, therefore, is basically a food technology problem. This means that the basic concepts of good harvest practice, of drying crops rapidly and keeping them dry in storage, transport and processing systems, will ensure that crops remain essentially free of ochratoxin A (FAO/WHO, 2008).

Contamination with *Aspergillus spp*. may occur before harvest in certain crops like maize, peanuts, tree nuts and cottonseed. With other crops, prevention of the formation of aflatoxins relies mainly on avoidance of contamination after harvest by use of rapid drying and good storage practice (IARC, 2012).

Following good agricultural practices during both pre-harvest and post-harvest stages should result in a minimization of the problem of contamination by mycotoxins such as aflatoxins and ochratoxin A (Atanda *et al.*, 2013). These authors propose three levels of prevention of the contamination by fungi and their mycotoxins in agricultural commodities in general: Primary (before the fungal infestation), Secondary (if the invasion of some fungi begins in commodities at early phase) and Tertiary prevention (once the products are heavily infested by toxic fungi).

Aflatoxin control should be focused on primary production since moulds invade crops in the field, by means of good storage practices and a final sorting of the harvest. Besides, mycotoxin-reducing processes should be considered once the spice is dry (final processing). There is, at least, one mycotoxin-reducing process authorized for spices (gamma irradiation) in some countries/regions. It has been proved to be efficient in eliminating fungi in chilli, coriander, cumin, turmeric (Alam *et al.*, 1992) and Ashanti pepper (Onyenekwe *et al.*, 1997). Moreover, other treatments utilized to reduce or eliminate toxigenic fungal spores in spices include UV as well as fumigation with ethylene oxide.

4.1 Existing Codes of Practice

Spain has produced and approved a Code of Practice for the prevention and reduction of ochratoxin A contamination in paprika at the national level, which can serve as a basis for this COP (AESAN, 2010) and is included as an Annex to this discussion document (Annex 2).

The Codex Code of hygienic practice for spices and dried aromatic plants (CAC, 1995) contains general provisions to prevent mycotoxin contamination in spices, such as certain precautions to be utilized during the drying process and the inclusion of the mycotoxin control of the raw material. This Codex COP has been amended recently by the Committee on Food Hygiene (CCFH, 2013) taking into account the COP approved by Spain and has been adopted by the Codex Alimentarius Commission (CAC, 2014). All the specific measures to prevent mycotoxins in spices are included in point 4.3 of this document (management practices for risk factors). The structure of this document will be discussed as a possibility for the COP for mycotoxins in spices in point 5 of this Discussion Document.

The Codex Code of Practice for the prevention and reduction of mycotoxin contamination in cereals (CAC, 2003) contains recommendations to control and manage contamination by various mycotoxins and is divided in two parts: recommended practices based on Good Agricultural Practice (GAP) and Good Manufacturing Practice (GMP); a complementary management system to consider in the future is Hazard Analysis Critical Control Point (HACCP) principles. The structure of this document will be discussed as a possibility for the COP for mycotoxins in spices in point 5 of this Discussion Document.

The IOSTA Guidelines for Good Agricultural Practices for Spices (IOSTA, 2008; IOSTA, 2013)focuses not only on good agricultural practices but also on further steps within the production chain be followed in order to avoid chemical and microbiological contamination of spices, including mycotoxins. All the specific measures to prevent mycotoxins in spices are included in point 4.3 of this document (management practices for risk factors). The structure of this document will be discussed as a possibility for the COP for mycotoxins in spices in point 5 of this Discussion Document.

There are some practical recommendations to avoid mycotoxin producing moulds during harvest and processing of several spices in the FAO Diversification Booklet 20 on Spices and herbs for home and market (Matthews and Jack, 2011).

The effectiveness of these good practices has been assessed (evidence to be provided by both member countries and observers). Therefore, this risk management measure has been proved to be effective in lowering the mycotoxin content in foodstuffs.

The guidelines for good practices are a valuable instrument to aid food business operators at all levels of the food chain to comply with the rules on food hygiene requirements and to apply the principles of HACCP.

4.2 Management practices for risk factors

4.2.1 Pre-harvest agicultural conditions

Significant levels of mycotoxins can occur in the food crops in the fields due to toxigenic fungal infection and growth. Good agricultural practices, reduction of plant stress through irrigation, mineral nutrition, cleaning of soil surface from crop residue, protection from insect damage etc. can mitigate the fungal growth. Good cultural practices viz. crop rotation, timely planting and harvesting and use of bio-pesticides have protective actions that reduce mycotoxin contamination of field crops.

Minimize insect damage and fungal infection in the vicinity of the crop by proper use of registered insecticides, fungicides and other appropriate practices within an integrated pest management program (CAC, 2003).

Introduction of atoxigenic strains of A. flavus and A. parasiticus to soil of developing crops has resulted in 74.3% to 99.9% reduction in AF contamination in peanuts in the USA (Dorner *et al.*, 1998).

The use of the yeast Saccharomyces cerevisiae reduced the AFB1 concentration in peanuts by 74.4%. Control of FUM-producing fungi by endophytic bacteria has also been reported. In vitro inhibition of OTA production by A. ochraceus by three yeasts (Pichia anomala,P. kluyveri and Hanseniaspora uvarum) was also reported (Masoud and Kaltoft, 2006; Bianchini and Bullerman, 2010; Hanif *et al.*, 2012; Jalili and Jinap, 2012).

Moreover, about these new opportunity in control strategies there is evidence that *Bacillus sp*., propionic acid bacteria and lactic acid bacteria (LAB) are able to inhibit fungal growth and mycotoxin production (Bianchini and Bullerman, 2010). And the International institute for agricultural research, IITA, has pioneered this technique in Nigeria by the development of its product called Aflasafe. Aflasafe has proven successful and is being tried on a number of crops (Bandyopadhyay and Cardwell, 2003).

4.2.1.1 Rotation

Apply a proper crop rotation to regenerate the soil fertility and reduce the inoculum load of the relevant mycotoxigenic fungi, to minimize the carry-over of moulds from one year to the next.

4.2.1.2 Residue

It is recommended to remove diseased and injured fruits from the field in order to reduce inoculum load of the relevant mycotoxigenic fungi.

4.2.1.3 Variety choice

Development of pest- resistant varieties of crops through new bio-technologies can reduce the possibility for mycotoxin contamination.

Varieties of chilli and peppers that have a thin pulp and have as high dry solid content as possible should be selected; these traits make the drying easier and faster.

4.2.1.4 Weeds and insects

It may also be necessary to use recommended insecticides, when conditions require, minimizing damage to fruits which may later favour entry and development of fungi; for example, through open galleries made by caterpillars. It may also be useful to establish an appropriate planting density and prevent weed proliferation during plant development.

Control weeds in the crop by use of mechanical methods or by use of registered herbicides or other safe and suitable weed eradication practices (CAC, 2003).

4.2.1.5 Fungicides

The use of recommended soil fungicides in the process of farm soil preparation may be beneficial to reduce the spore load of mycotoxin-producing fungi. At sowing, use disinfected seeds to prevent mold and insects and carefully choose the planting season so that the collection of fruits takes place in the driest season. This good practice is essential in areas with warm and humid climate.

The use of chemical compounds is a very effective strategy to prevent mycotoxin production (FAO/WHO/UNEP, 1999). If it's possible to add treatments with chemicals, including sodium bisulfite, ozone, and ammonia, **acids and bases**, that represent an opportunity to control fungal growth and mycotoxin biosynthesis in stored grains (Bozoglu, 2009; Magan, 2006; Magan & Aldred, 2007). However, fungicides must be applied with special care since some of them, such as carbendazim, have been found to reduce fungal flora but also to stimulate Ochratoxin A production (Medina *et al.*, 2007). Therefore, the use of fungicides should be monitored by experts.

4.2.2 Post-harvest agricultural conditions

4.2.2.1 Harvest

Chances for mechanical damage of seeds during harvesting may be avoided so that subsequent contamination can be significantly reduced. Field crops should be harvested in timely manner to reduce moisture or water activity (a_w) level to a point where mycotoxin formation will not occur.

Fusarium can produce more mycotoxins once a crop has ripened if harvest is delayed due to wet weather or any other reason. Diseased and injured fruits must be removed after harvesting. In case of severe drought before harvesting, crops should be irrigated moderately to avoid stress yet not to cause vine berry damage which promotes infection by mycotoxins producing *Aspergillus*. Minimize mechanical damage to plants during cultivation (CAC, 2003).

The soil under the plant should be covered with a clean sheet of plastic during picking to avoid fruits getting contaminated by dirt or mixed up with mouldy fruits that have fallen prior to harvesting. Fallen fruit and leaves should be removed from the area as they provide the correct growing substrate for moulds.

Fruits that have fallen to the ground are known to be susceptible to mould growth. Fruits that are affected by mould or infected should be removed. Alternatively, the raw spice fallen to the ground should be collected separately, washed, cleaned, dried and evaluated prior to any inclusion within the main lot.

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 mycotoxins generation from overripe fruits (IOSTA, 2013).

4.2.2.2 Storage (fresh product)

Gunny bags should be stored off the floor (on pallets) and away from the walls so that any potential condensation does not rewet the product and to avoid the chance of entering moisture from the wall (IOSA, 2008). Internal walls, surface and the junctions of the floor with the walls and the junction 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 the contamination and spoil the crop. Hence it should be controlled. If possible, only the amount that can be processed in a timely manner should be picked in order to minimize growth of mycotoxin-producing moulds prior to processing (CCFH, 2013).

Proper storage is necessary to prevent biological activity through adequate drying to less than 10% moisture, elimination of insect activity that can increase moisture content through condensation of moisture resulting from respiration, low temperatures, and inert atmospheres. The storage facilities should include dry, well-vented structures that provide protection from rain, drainage of ground water, protection from entry of rodents and birds, and minimum temperature fluctuations (CAC, 2003).

Another paragraph should be included dealing with a cleaning and disinfection plan and the use of non-toxic antifungi cleaning products, such as propionic acid and acetic acid.

4.2.2.3 Transport from storage

During transportation, due attention should be given to avoid re-entering of water/moisture in to the commodity and pests or debris cannot penetrate to the commodity.

The time between harvesting and drying should be as short as possible, including transport from the field to post-harvest facilities.

The containers and conveyances for transporting the source plant material or spices and dried aromatic herbs from the place of production to storage for processing should be cleaned and disinfested, as appropriate, before loading. Products should be protected, where practicable, against outdoor conditions when transported. Covering should be provided to prevent rain, pests or debris from getting onto the commodity.

Prevent field debris from entering packing and storage facilities by cleaning the outside of harvest bins and requiring workers to wear clean clothes in those areas.

Spices and dried aromatic herbs should be kept in areas where contact with water or moisture is minimized.

Spices and dried aromatic herbs should be stored on raised platforms or hung under a non-leaking roof in a cool dry place. The storage location should prevent access, to the extent practicable, by rodents or other animals and birds and should be isolated from areas of excessive human or equipment traffic (CCFH, 2013).

Document the harvesting and storage procedures implemented each season by making notes of measurements (e.g., temperature, moisture, and humidity) and any deviation or changes from traditional practices. This information may be very useful for explaining the cause(s) of fungal growth and mycotoxin formation during a particular crop year and help to avoid similar mistakes in the future (CAC, 2003).

Further recommendations for containers, stuffing and shipping are detailed in the IOSTA Guidelines for Good Agricultural Practices for Spices (IOSTA, 2013).

4.2.3 Industrial processing conditions

4.2.3.1 Sorting

Raw materials should be inspected and sorted prior to introduction into the processing line. The inspection may include visual inspection of foreign matters, organoleptic evaluation or tests for mycotoxin contamination.

4.2.3.2 Processing (drying, grinding, mixing, sterilization)

It is necessary the separation between raw material receipt, cleaning, washing, and processing, to prevent any cross-contamination.

In case the drying process cannot be applied immediately, fresh fruits should be stored under a relative humidity below 80% and a temperature below12 ºC to prevent the proliferation of OTA producing fungi.

In case of grinding, thorough cleaning of the mechanical parts of the grinding mill to be ensured to avoid carry-over from the previous milling. Rinsing (grinding and discarding with a minimum quantity of the commodity) is recommended during the milling.

Two recommendations that could affect any of these steps:

A) Identify concrete specifications when it may be a measure of control of mycotoxins (e.g. drying paprika at 70-72ºC) and differentiate the processing of other spices (technological phase but not a specific control phase of mycotoxin e.g. ground saffron in cold storage at 2° C Temperature).

B) Define conditions of the final product, which can vary for each kind of spice and can be related to the growth control of mycotoxins.

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 spices and dried aromatic herbs (CCFH, 2013) as well as in the IOSTA Guidelines for Good Agricultural Practices for Spices (IOSTA, 2013).

It is recommended that drying temperature increases to 72 Celsius degrees and humidity be reduce to 12%.

Sterilization processes should be explained.

4.2.3.3 Storage (post-drying)

Gunny bags should be stored off the floor (on pallets) and away from the walls so that any potential condensation does not rewet the product and to avoid the chance of entering moisture from the wall (IOSA, 2008). Internal walls, surface and the junctions of the floor with the walls and the junction between two walls should be made with a smooth, water-proof, non-absorbent, washable and non-toxic material.

A) Specific conditions to be utilized include the use of local ventilation systems that force the production of currents of cold, dry air to assure good ventilation, and storage in a clean, dry place, protected from dust, debris, insects and rodents. Product should be stored in good, well maintained warehouses that do not allow the ingress of water whether through leaks in the roof or walls or under doors, through open windows etc.

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 rewet the product. In addition there should be good air movement through the warehouse to prevent sweating and mould formation.

Temperature levels within large warehouses can be ideal for mould growth, particularly towards the roof, thus suitable ventilation should be provided to ensure that both temperature and humidity are correctly managed.

When product is moved into or out of the warehouse ensure it is protected from the rain during transportation.

Make regular checks 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 would 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. This also prevents cross contamination from previously transported products (see allergens).

Trucks should not be loaded and unloaded if the product has the potential to be exposed to rain. Shelter should be provided so that the spice does not get wet during this operation (IOSTA, 2013).

B) specific good storage practices to be applied so as to ensure proper administration of the product to avoid unnecessary retention and prolonged storage (FAO, 2001).

4.2.3.4 Packaging

Appropriate packaging is a successful way to avoid insects and moulds. During packing, any chance of contact to moisture should be avoided. The possible use of packaging with intelligent materials which absorb humidity should be explored.

The modified atmosphere packaging conditions inhibited growth and reduced aflatoxin production of *A. flavus* (Ellis et al., 1993). Sealed or vacuum conditions can prevent mycotoxin occurrence of red chili pepper during storage (Duman, 2010).

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

When packing spices and dried aromatic herbs in the growing/harvest area for transport, storage, or for further sale, new bags should be used to prevent the potential for microbial, physical and chemical contamination. When bags are marked, food-grade ink should be used to minimize the potential for contamination with ink. When bags have an open structure, such as jute bags, the bag should not be marked when filled with spices and dried aromatic herbs to prevent liquid ink from contaminating the contents and increasing the moisture in the spices and dried aromatic herbs. It is recommended that paper tags be used instead of liquid ink for marking.

Containers should be inspected immediately before use to ensure that they are in a satisfactory condition 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 would promote the presence of pests (CCFH, 2013).

Two recommendations that could affect this step:

A) the use of packaging impervious to water in order to maintain humidity below 12% (CAC, 1995).

B) using packaging technologies that ensure the maintenance of moisture as vacuum or modified atmosphere (Soriano, 2007).

4.2.3.5 Labeling and distribution/information to consumers

Three recommendations in this phase:

A) Indicate the date of minimum durability: the operator shall justify by appropriate studies that takes into account the characteristics of the packaging, the most unfavorable conditions and verification of the final product in order to give assurance of no mycotoxins contamination until the end of their consumption.

B) Indicate specific storage instructions: cool, dry, well-ventilated area away from heat sources such as ovens and humidity, avoid storing in a refrigerator to prevent condensation, etc.

C) Specify tips for good use by the consumer to minimize the risk of mycotoxins contamination: avoid contact with wet utensils and wooden spoons. Close containers immediately after use, avoid unnecessary stockpiling and always check dates of preferred consumption (Raghavan, 2006).

4.3 Research currently under way

Research currently under way in Sudan includes work on: garlic (*Allium sativum*), fenugreek (*Trigonella foenum*), coriander (*Coriandrum sativum*), hot pepper (Capsicum annum) and cumin (*Cuminum cyminum*). Research areas includes: Evaluation of some local and introduced germplasm under various production regions amd the development of the optimum production technologies and collection and maintenance of local races.

4.4 Conclusion on availability of risk management measures for a COP

There are key documents at the international level and new scientific evidence which make it possible to compile enough management measures to draft a COP for the prevention of mycotoxin contamination in spices in general. However, in spite of the current research work on several spices, there is not enough evidence available neither for risk management measures for each spice or group of spices nor for the evaluation of the application of the existing general management practices on each spice.

5 POSSIBLE STRUCTURE OF A CODE OF PRACTICE ON MYCOTOXINS IN SPICES

The aim of this draft Code of Hygienic Practice is to address specific Good Agricultural Practices (GAPs), Good Manufacturing Practices (GMPs) and Good Storage Practices (GSPs) that would help minimize mycotoxin contamination throughout all stages of the production of spices and dried aromatic herbs from primary production to consumer use. A HACCP system should be built on sound GAPs, GMPs and GSPs. Good Agricultural Practices (GAPs) are applied at the pre-harvest level, Good Manufacturing Practices (GMPs) during the processing and Good Storage Practices during the storage and distribution of various products.

The structure of the Codex Code of practice on mycotoxins in spices could follow several structures:

a) The same structure as the Codex Code of practice for the prevention and reduction of mycotoxin contamination in cereals, including annexes on ochratoxin A, zearalenone, fumonisins and trichothecenes (CAC, 2003) could be used, that is to say, it can be comprised of a main body with an introduction and the description of general recommended practices to prevent mycotoxin contamination in spices, based on good agricultural practices (GAP) and good manufacturing practices (GMP), followed by several annexes for each mycotoxin/spice or group of spices (to be considered) to be taken into account under the Hazard Analysis Critical Control Point (HACCP) system.

b) The recently amended Codex Code of hygienic practice for spices and dried aromatic plants (CAC, 1995; CCFH, 2013) is a comprehensive document that comprises an introduction and several sections: Objectives, Scope, use and definitions, Primary production, Establishment (design and facilities), Control of Operation (dealing with HACCP key points), Establishment (maintenance and sanitation), Establishment (personal hygiene), Transportation, Product information and consumer awareness and Training.

c) The IOSTA Guidelines for Good Agricultural Practices for Spices (IOSTA, 2008; IOSTA, 2013) focuses not only on good agricultural practices but also on further steps of the production chain to avoid, among others, mycotoxin contamination. This document can be a good reference to fill several gaps in the former Codex documents, since it includes recommendations for the following steps: growing, harvesting, drying, processing, storage and transportation and containers, stuffing and shipping. However, this is not a comprehensive document and does not cover as many aspects as the former Codex documents.

d) The Code of Practice for the prevention and reduction of ochratoxin A contamination in paprika approved in Spain (AESAN, 2010), included as an Annex to this discussion document (Annex 2), has a simple structure including an Introduction, Definitions, Description of the spice production (paprika in this case) and finally the recommended practices (before harvest, during harvest, post-harvest, transport, processing and storage).

The proposed structure for the code of practice for mycotoxins in spices would be a mixture of the four documents discussed above and would be as follows:

5.1 Main body

The main body could include an Introduction and, for the sake of simplicity, the following sections:

1. Objectives

2. Scope, use and definitions

3. General recommended practices to avoid mycotoxin formation in spices throughout the food chain (including GAP, GMP and GSP, since there is no clear separation).

5.2 Annexes

Different annexes could be developed based on different criteria, e.g. by “mycotoxin” (as the COP for mycotoxins in cereals), by “group of mycotoxins”, by “spice” or by “group of spices”.

Since there is a Codex EWG working on grouping of spices and the risk of mycotoxin contamination is presumed to be very similar within the group, the proposal of this EWG is to add different annexes for each group of spices, where the spice production could be approached together with specific management practices (if applicable) to avoid the most common mycotoxins affecting those spices. In case no information on specific management practices is available, reference to the main body of the COP should be made (similar to the COP for mycotoxins in cereals). The document would be amended and updated as long as new evidence is found.

The Annex to this discussion paper (the Spanish Code of Practice for OTA in paprika) is presented as an example of a possible annex to the COP on mycotoxins in spices. Several aspects could be moved from this specific COP to the main body of the COP on mycotoxins in spices keeping only the particular conditions for preventing mycotoxin contamination in paprika and including some provisions for aflatoxins. If these particular conditions could be extrapolated to other spices within the group of “dried fruits, roots and berries” (nutmeg, ground ginger, pepper, star anise and vanilla), the annex could refer to specific preventive measures for the whole group of spices.

6 CONCLUSIONS ON THE FEASIBILITY OF A COP FOR PREVENTION AND REDUCTION OF MYCOTOXINS IN SPICES

There is sufficient evidence to develop a COP for the prevention and reduction of mycotoxins in spices and there is general agreement on the structure proposed. Therefore, it is feasible at this time to work on such a COP, taking into account the progress made by other Codex EWGs (e.g. prioritization of the work on MLs for mycotoxins in spices, grouping of spices, revision of the COP on mycotoxins in cereals).

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ANNEX 2: PROPOSED DRAFT CODE OF PRACTICE FOR THE PREVENTION AND REDUCTION OF MYCOTOXINS IN SPICES

Since there is general agreement within the EWG on the structure of the proposed COP, and taking into account all the information compiled in point 4 of the Discussion Paper, the proposed draft COP would have the following content:

General part

1. Objectives

The objective of this document is to establish a general code of practice for the prevention and reduction of mycotoxins in spices and dried aromatic herbs in order to reduce their presence in spices to the lowest achievable level by applying good practices throughout all the steps in the food chain, thus reducing consumers exposure to mycotoxins through preventive measures.

2. Scope, use and definitions

Scope

This Code applies to spices and dried aromatic herbs - whole, broken, ground or blended. Spices and dried aromatic herbs may include the dried aril (e.g. the mace of nutmeg), bark (e.g. cinnamon), berries (e.g. black pepper), buds (e.g. clove), bulbs (e.g. dried garlic), leaves (e.g. dried basil), rhizomes (e.g. ginger, turmeric), seeds (e.g. mustard), stigmas (e.g. saffron), pods (e.g. vanilla), resins (e.g. asafoetida), fruits (e.g. dried chilli) or plant tops (e.g. dried chives) (CCFH, 2013).

Use

This Code is a recommendation to which producers in different countries should adhere as far as possible taking into account the local conditions while ensuring the safety of their products in all circumstances. Flexibility in the application of certain requirements of the primary production of spices and dried aromatic herbs can be exercised, where necessary, provided that the product will be subjected to control measures sufficient to obtain a safe product (CCFH, 2013).

Definitions

Apart from the definitions mentioned in point 1.3 of the Discussion Document, the following definition is proposed to be added:

Source Plant: plant (non-dried) from which the spice or dried aromatic herb is derived (CCFH, 2013).

3. General recommended practices to avoid mycotoxin formation in spices throughout the food chain (including GAP, GMP and GSP, since there is no clear separation):

3.1 Pre-harvest agricultural conditions

Significant levels of mycotoxins can occur in the food crops in the fields due to toxigenic fungal infection and growth. Good agricultural practices, reduction of plant stress through irrigation, mineral nutrition, cleaning of soil surface from crop residue, protection from insect damage etc. can mitigate the fungal growth. Good cultural practices viz. crop rotation, timely planting and harvesting and use of bio-pesticides have protective actions that reduce mycotoxin contamination of field crops.

Minimize insect damage and fungal infection in the vicinity of the crop by proper use of registered insecticides, fungicides and other appropriate practices within an integrated pest management program.

3.1.1 Rotation

Apply a proper crop rotation to regenerate the soil fertility and reduce the inoculum load of the relevant mycotoxigenic fungi, to minimize the carry-over of moulds from one year to the next.

3.1.2 Residue

It is recommended to remove diseased and injured fruits from the field in order to reduce inoculum load of the relevant mycotoxigenic fungi.

3.1.3 Variety choice

Development of pest- resistant varieties of crops through new bio-technologies can reduce the possibility for mycotoxin contamination.

Varieties of chilli and peppers that have a thin pulp and have as high dry solid content as possible should be selected; these traits make the drying easier and faster.

3.1.4 Weeds and insects

It may also be necessary to use recommended insecticides, when conditions require, minimizing damage to fruits which may later favour entry and development of fungi; for example, through open galleries made by caterpillars. It may also be useful to establish an appropriate planting density and prevent weed proliferation during plant development.

Control weeds in the crop by use of mechanical methods or by use of registered herbicides or other safe and suitable weed eradication practices.

3.1.5 Fungicides

The use of recommended soil fungicides in the process of farm soil preparation may be beneficial to reduce the spore load of mycotoxin-producing fungi. At sowing, use disinfected seeds to prevent mold and insects and carefully choose the planting season so that the collection of fruits takes place in the driest season. This good practice is essential in areas with warm and humid climate.

The use of chemical compounds is a very effective strategy to prevent mycotoxin production. However, fungicides must be applied with special care since some of them, such as arbendazim, have been found to reduce fungal flora but also to stimulate Ochratoxin A production. Therefore, the use of fungicides should be monitored by experts.

3.2 Post-harvest agricultural conditions

3.2.1 Harvest

Chances for mechanical damage of seeds during harvesting may be avoided so that subsequent contamination can be significantly reduced. Field crops should be harvested in timely manner to reduce moisture or water activity (a_w) level to a point where mycotoxin formation will not occur.

Fusarium can produce more mycotoxins once a crop has ripened if harvest is delayed due to wet weather or any other reason. Diseased and injured fruits must be removed after harvesting. In case of severe drought before harvesting, crops should be irrigated moderately to avoid stress yet not to cause vine berry damage which promotes infection by mycotoxins producing *Aspergillus*. Minimize mechanical damage to plants during cultivation.

The soil under the plant should be covered with a clean sheet of plastic during picking to avoid fruits getting contaminated by dirt or mixed up with mouldy fruits that have fallen prior to harvesting. Fallen fruit and leaves should be removed from the area as they provide the correct growing substrate for moulds.

Fruits that have fallen to the ground are known to be susceptible to mould growth. Fruits that are affected by mould or infected should be removed. Alternatively, the raw spice fallen to the ground should be collected separately, washed, cleaned, dried and evaluated prior to any inclusion within the main lot.

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 mycotoxins generation from overripe fruits.

3.2.2 Storage (fresh product)

Gunny bags should be stored off the floor (on pallets) and away from the walls so that any potential condensation does not rewet the product and to avoid the chance of entering moisture from the wall. Internal walls, surface and the junctions of the floor with the walls and the junction 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 the contamination and spoil the crop. Hence it should be controlled. If possible, only the amount that can be processed in a timely manner should be picked in order to minimize growth of mycotoxin-producing moulds prior to processing.

Proper storage is necessary to prevent biological activity through adequate drying to less than 10% moisture, elimination of insect activity that can increase moisture content through condensation of moisture resulting from respiration, low temperatures, and inert atmospheres. The storage facilities should include dry, well-vented structures that provide protection from rain, drainage of ground water, protection from entry of rodents and birds, and minimum temperature fluctuations.

3.2.3 Transport from storage

During transportation, due attention should be given to avoid re-entering of water/moisture in to the commodity and pests or debris cannot penetrate to the commodity.

The time between harvesting and drying should be as short as possible, including transport from the field to post-harvest facilities.

The containers and conveyances for transporting the source plant material or spices and dried aromatic herbs from the place of production to storage for processing should be cleaned and disinfested, as appropriate, before loading. Products should be protected, where practicable, against outdoor conditions when transported. Covering should be provided to prevent rain, pests or debris from getting onto the commodity.

Prevent field debris from entering packing and storage facilities by cleaning the outside of harvest bins and requiring workers to wear clean clothes in those areas.

Spices and dried aromatic herbs should be kept in areas where contact with water or moisture is minimized.

Spices and dried aromatic herbs should be stored on raised platforms or hung under a non-leaking roof in a cool dry place. The storage location should prevent access, to the extent practicable, by rodents or other animals and birds and should be isolated from areas of excessive human or equipment traffic.

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

Further recommendations for containers, stuffing and shipping are detailed in the IOSTA Guidelines for Good Agricultural Practices for Spices.

3.3 Industrial porcessing conditions

3.3.1 Sorting

Raw materials should be inspected and sorted prior to introduction into the processing line. The inspection may include visual inspection of foreign matters, organoleptic evaluation or tests for mycotoxin contamination.

3.3.2 Processing (drying, grinding, mixing, sterilization)

It is necessary the separation between raw material receipt, cleaning, washing, and processing, to prevent any cross-contamination.

In case the drying process cannot be applied immediately, fresh fruits should be stored under a relative humidity below 80% and a temperature below 12 ºC to prevent the proliferation of OTA producing fungi.

In case of grinding, thorough cleaning of the mechanical parts of the grinding mill to be ensured to avoid carry-over from the previous milling. Rinsing (grinding and discarding with a minimum quantity of the commodity) is recommended during the milling.

Two recommendations that could affect any of these steps:

A) Identify concrete specifications when it may be a measure of control of mycotoxins (e.g. drying paprika at 70-72ºC) and differentiate the processing of other spices (technological phase but not a specific control phase of mycotoxin e.g. ground saffron in cold storage at 2° C Temperature).

B) Define conditions of the final product, which can vary for each kind of spice and can be related to the growth control of mycotoxins.

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 spices and dried aromatic herbs as well as in the IOSTA Guidelines for Good Agricultural Practices for Spices.

It is recommended that drying temperature increases to 72 Celsius degrees and humidity be reduce to 12%.

3.3.3 Storage (post-drying)

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

A) Specific conditions to be utilized include the use of local ventilation systems that force the production of currents of cold, dry air to assure good ventilation, and storage in a clean, dry place, protected from dust, debris, insects and rodents. Product should be stored in good, well maintained warehouses that do not allow the ingress of water whether through leaks in the roof or walls or under doors, through open windows etc.

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 rewet the product. In addition there should be good air movement through the warehouse to prevent sweating and mould formation.

Temperature levels within large warehouses can be ideal for mould growth, particularly towards the roof, thus suitable ventilation should be provided to ensure that both temperature and humidity are correctly managed.

When product is moved into or out of the warehouse ensure it is protected from the rain during transportation.

Make regular checks 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 would 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. This also prevents cross contamination from previously transported products (see allergens).

Trucks should not be loaded and unloaded if the product has the potential to be exposed to rain. Shelter should be provided so that the spice does not get wet during this operation.

B) specific good storage practices to be applied so as to ensure proper administration of the product to avoid unnecessary retention and prolonged storage.

3.3.4 Packaging

Appropriate packaging is a successful way to avoid insects and moulds. During packing, any chance of contact to moisture should be avoided. The possible use of packaging with intelligent materials which absorb humidity should be explored.

The modified atmosphere packaging conditions inhibited growth and reduced aflatoxin production of *A. flavus*. Sealed or vacuum conditions can prevent mycotoxin occurrence of red chili pepper during storage.

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

When packing spices and dried aromatic herbs in the growing/harvest area for transport, storage, or for further sale, new bags should be used to prevent the potential for microbial, physical and chemical contamination. When bags are marked, food-grade ink should be used to minimize the potential for contamination with ink. When bags have an open structure, such as jute bags, the bag should not be marked when filled with spices and dried aromatic herbs to prevent liquid ink from contaminating the contents and increasing the moisture in the spices and dried aromatic herbs. It is recommended that paper tags be used instead of liquid ink for marking.

Containers should be inspected immediately before use to ensure that they are in a satisfactory condition 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 would promote the presence of pests.

Two recommendations that could affect this step:

A) the use of packaging impervious to water in order to maintain humidity below 12%.

B) using packaging technologies that ensure the maintenance of moisture as vacuum or modified atmosphere.

3.3.5 Labeling and distribution/information to consumers

Three recommendations in this phase:

A) Indicate the date of minimum durability: the operator shall justify by appropriate studies that takes into account the characteristics of the packaging, the most unfavorable conditions and verification of the final product in order to give assurance of no mycotoxins contamination until the end of their consumption.

B) Indicate specific storage instructions: cool, dry, well-ventilated area away from heat sources such as ovens and humidity, avoid storing in a refrigerator to prevent condensation, etc.

C) Specify tips for good use by the consumer to minimize the risk of mycotoxins contamination: avoid contact with wet utensils and wooden spoons. Close containers immediately after use, avoid unnecessary stockpiling and always check dates of preferred consumption.

Annexes: Annex 1

(*Used as an example. To be modified in future discussions of the CCCF according to the Discussion Document*)

PREVENTION AND REDUCTION OF CONTAMINATION BY OCHRATOXIN A AND AFLATOXINS IN SPICES OF DRIED FRUITS, ROOTS AND BERRIES (e.g. PAPRIKA)

1. INTRODUCTION

Ochratoxin A (OTA) is a toxic fungal metabolite classified by the International Agency for Research on Cancer (IARC) as a possible human carcinogen (Group 2B). The Scientific Panel on Contaminants in the Food Chain of the European Food Safety Authority (EFSA) has evaluated the risk of OTA through food intake[2] and has established a Tolerable Weekly Intake (TWI) of 120 ng / Kg_{bw}.day.

OTA is produced when conditions of water activity, temperature and nutrition needed for growth of fungi of the genera *Aspergillus* and *Penicillium* are present. OTA contamination can occur during cultivation, and due to its chemical structure, is stable during storage and resists, generally, industrial processing procedures. The main commercial pepper variety produced and traded is *Capsicum annuum*.

After harvest, the crop is sorted, washed (optional at this stage), dried (sun or hot air dryers), stored and traded. The moisture content and temperature of the skin must be kept low to prevent the OTA production.

The purpose of this code of practice is to serve as a guide of good hygiene practices in order to prevent and reduce the OTA content in paprika, reaching the lowest levels possible (ALARA principle), providing practical information to help the industry involved to comply with the maximum limits set out in legislation[3].

2. DEFINITIONS

Paprika is the dried product obtained from the grinding of sorted healthy and clean fruits of several red varieties (and in this case sweet) of the genus *Capsicum* (pepper).

3. PAPRIKA PRODUCTION

The traditional production process is described in Figure 1.

The average yield of the process with respect to fresh produce is less than 15% (about 5-10 kg of fresh pepper to obtain 1 kg of pods). In the overall process 5-6% of the powder is lost.

The application of hazard analysis and critical control point (HACCP) techniques during the stages of production, drying, transport, processing and storage are essential to prevent the risk of a high content of OTA in the paprika.

It is also mandatory to have a traceability control system and different records to ensure proper implementation of HACCP.

4. RECOMMENDED PRACTICES

4.1 BEFORE HARVEST

In geographic areas where climatic conditions are favorable for contamination by mycotoxin-producing fungi (warm temperatures and high humidity), authorized fungicides should be applied, especially during fruit ripening, taking into account the maximum residue limits (MRLs) in force in the European Union (Regulation (EC) No 396/2005) and the corresponding processing factor due to desiccation, which is 5-6, but it is estimated that it can reach a value of 10.

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[2] Opinion of the Scientific Panel on contaminants in the food chain [CONTAM] related to ochratoxin A in food. *The EFSA Journal (2006) 365, 1 – 56*

[3] Commission Regulation (EU) 105/2010 of February 2010 amending Regulation (EC) 1881/2006 setting maximum levels for certain contaminants in foodstuffs as regards ochratoxin A

Even though OTA-forming fungi are present in the earth, there is no evidence that they infect the raw material while it is still on the plant. However, although unlikely, this situation could happen as it occurs in other crops such as coffee.

Recommended agricultural practices to prevent the development and spore load from OTA- producing fungi on pepper plants are:

a) Implementation of regular good agricultural practices (GAP) at the proper time, such as weeding, improving soil texture and aeration, pruning, fertilization and proper irrigation. A soil with good drainage must be chosen in order to avoid accumulation of irrigation water.

b) The use of soil fungicides (metam-sodium, chloropicrin, 1,3-dichloropropene, etc.[4]) in the tasks of farm soil preparation may be beneficial to reduce the spore load of OTA-producing fungi. At sowing, use disinfected seeds to prevent mold and insects and carefully choose the planting season so that the collection of peppers takes place in the driest season. This good practice is essential in areas with warm and humid climate.

c) It is also essential the use of pesticides, whenever conditions require, thus minimizing fruits damage that may favor the entry and development of fungi, for example, through open galleries made by caterpillars. Establish an appropriate plant density and prevent weeds proliferation during plant development.

d) It is advised that spray irrigation be avoided during the flowering period. This could increase both the rate of normal dispersion of spores and the chances of fruit infection with OTA-producing fungi.

e) It is recommended that untreated organic waste not be applied to soil surrounding the crop in the field as it could allow the proliferation of OTA-producing fungi.

f) It is imperative that all tools used during cultivation be thoroughly cleaned and disinfected before use.

g) Apply a proper crop rotation to regenerate the soil.

4.2 HARVESTING

It is important to collect the peppers in the optimum point of ripeness, when they present their most intense color, which indicates a higher content of natural pigments and lower water content.

Personnel involved in the task of collection should be properly trained in the prevention of mycotoxin contamination. During the collection of the crop there should be an appropriate selection of fruits, discarding those showing symptoms of fungal contamination and those that present some kind of external damage. These fruits discarded should be removed from the planting area, thus avoiding contaminating the soil for cultivation. It is very important that during harvesting the peppers do not fall onto the ground so as to prevent contamination.

The boxes, containers and vehicles where the fruits are transported, as well as the tools used to collect them, should be properly cleaned and disinfected, in accordance with the principles of food hygiene[5].

It is also recommended to develop a control system for the OTA contamination in the production areas, as well as research studies on the factors affecting the formation of this mycotoxin.

4.3 POST-HARVEST

Freshly picked peppers should be moved to the dryer for processing as soon as possible after harvesting. The containers to be used to transport the peppers from farm to drying facilities must be clean, disinfected and dried before use or reuse. They must be suitable for the intended load. Pepper collected should always be protected from rain or moisture.

Fresh fruits should be stored under a relative humidity below 80% and a temperature between 7-12 ºC to prevent the proliferation of OTA producing fungi until they are dried.

[4] It has to be previously checked if the use of these products is allowed by the country legislation.
[5] Regulation (EC) 852/2004 of the European Parliament and of the Council of 29 April 2004 on the hygiene of foodstuffs

4.3.1 Cleaning

Prior to drying, the harvested fruits should be washed to remove organic debris and dust, for which chlorinated water (100-150 ppm) can be used, rinsing afterwards to remove all traces of treatment. During this phase there should be a selection process to eliminate any peppers showing symptoms of fungal infection, and small sections of any contaminates fruit should be removed, because they can be the basis to contaminate a whole batch. This procedure can be carried out on the farm. The discarded materials are properly disposed of so as to not have recontamination of the clean material.

4.3.2 Drying

The main purpose of the drying operation is to efficiently decrease the high water content of the just harvested peppers in order to get a stable and good quality product. To prevent the growth of OTA producing fungi, the fruit should be kept under low humidity conditions during the drying process and the moisture content in the final product should be below 11%. The drying process produces a dried product whose composition on a dry base is approximately 33% of seed, 8% of stalk and 58.5% of pod.

The fruits can be dried either using direct sun (taking 3 or 4 days during periods of high temperatures and 7 or 8 in colder seasons) or in hot-air mechanical driers using air of low relative humidity (RH) and temperature of 45-65 °C (from 10-12 hours). In areas where climatic conditions of high humidity and mild temperatures is preferable to use hot air dryers, since the sun drying process can be extended up to 20-25 days, which favors the growth of OTA producing fungi.

The OTA-producing fungi require favorable conditions during a certain period of time to grow and produce the toxin. The level of available water is the most important factor to be considered. At high water activity (a_w> 0.95) OTA-producing fungi will not likely grow, as fast-growing hydrophilic fungi and yeasts grow first. At lower water activity (a_w <0.80) the OTA-producing fungi can be present but not produce the toxin, and at a_w below 0.78-0.76 they cannot grow.

Therefore the most important point is to control the period of time in which the pepper stays in the drying yard, in the range of water activity where OTA-producing fungi can grow (a_w = 0.8-0.95). According to experimental results, five days or less in the drying yard is enough and effective to prevent OTA accumulation.

Recommended measures to dry the peppers efficiently are:

a) The drying yard should have sufficient slope to facilitate removal of water and 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 fruits. Shady and low areas should be avoided. The fruits should be placed on elevated platforms or at least on a floor made up of suitable material free from contamination. The FCMs should be adequate to come into contact with food and that they should not favour the proliferation of fungi or the production of mycotoxins.

b) The surface for the drying yard should be selected according to the climate of the region, cost and quality of the dried product, as any type of surface has advantages and disadvantages. The use of plastic canvases in humid areas is inadequate, since it results in humidity developing under the pepper layer, promoting fungal growth. It is necessary that the drying surface be cleanable easy to disinfect.

c) It is very important that the peppers are not in direct contact with the ground, according to section 3.2 of the Code of Hygienic Practice for Spices and Dried Aromatic Plants, as it is the main contamination source.

d) The fresh concrete floors may be used for the drying phase only when there is absolute certainty that the concrete is properly filled and free of excess water. It is more hygienic to place a plastic cover (suitable for food) covering the entire floor of fresh concrete as a moisture protection.

e) 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.

f) Precautions must be taken to protect the fruit from contact with domestic animals, rodents, birds, mites, insects and other arthropods during the processes of drying, handling and storage.

g) Workers in the drying yard should be properly trained in the prevention of mycotoxin contamination, including the proper use of the moisture measuring equipment.

h) Repair, clean, protect and maintain 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 according to the ISO 6673 method.

i) During the drying process, the peppers should be turned to produce a uniform drying and damaged fruits should be discarded. Accumulation of fruits must also be avoided since it hampers the drying process and, therefore, increases its time. They should be extended to the utmost to facilitate aeration. More information is needed on how often the peppers are turned and what method is used to turn them.

4.3.3 Sorting and packaging

Once the peppers are dried, all stained, immature, discolored and damaged fruits should be discarded. The elimination of a single piece of a contaminated fruit is not a preventive measure for the OTA contamination but it may contribute to increase the OTA levels of rest of the fruit, giving rise to the contamination of the entire batch or even other consignments that may be mixed.

Dried peppers should be inspected and sorted before carrying out the further processing and be submitted for laboratory analysis to determine the OTA levels, either in a systematic way in samples from areas with unfavorable weather conditions (high humidity and mild temperature), or on a regular basis in samples from areas where the contamination is low.

It is important to evaluate the effectiveness of the screening technique; hence it is necessary to keep the analytical results of all batches in order to demonstrate that effectiveness.

After removing the stalk (optional), and in case the peppers are not going to be processed immediately, the product is eventually compacted into bales.

The presses used must be clean and in good condition. Breathable and suitable for food contact raffia bags must be used, that should be tightly closed to prevent from insects or pests contamination. The dry pepper packed in bales should be stored in a closed warehouse, clean and ventilated, always protected from moisture. It would be helpful to explain what the presses are and how they are used.

4.4 TRANSPORTATION

The containers to be used to transport the dried pepper to milling facilities must be clean, dry and free of insects and visible fungal growth before use or reuse.

The batches should be protected from any accumulation of additional moisture by using covered or airtight containers or tarpaulins. Temperature fluctuations should be avoided since it may cause condensation on the product, leading to local accumulation of moisture and the subsequent development of OTA-producing fungi. It would be helpful to describe the types of containers to be used.

During ship transportation, precautions should be taken and temperature and humidity sensors should be used inside the containers in order to detect fluctuations that might cause contamination during transport. In addition, the cargo holds should be well ventilated with dry air to remove moisture resulting from respiration of spices and prevent condensation when moving from a warm area to a colder one, or overnight.

Bags of dried peppers should be well stacked and crossed over for mutual support in order to avoid the formation of empty vertical columns (chimneys). The top layer and sides of bags should be covered with materials that can absorb condensed water, such as silica gel or cardboard for protection against the growth of fungi that could result in OTA production.

During transportation, infestation by insects, birds and rodents should be avoided by using either containers resistant to insect and rodent, or authorized repellent chemical treatments. As an effective option, the pepper transported in containers can be fumigated with magnesium or aluminum phosphide.

During peppers loading and unloading, areas should be covered to protect against rain.

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

4.5 PROCESSING OF THE DRIED PEPPER

The pepper should be processed as soon as possible at the processing plant.

The dried pepper is processed in a series of stages: Seeds elimination, crushing, grinding, cooling, mixing, sifting and sterilization. It would be helpful to explain the sterilization process.

After sterilization, the paprika is dried at 70 ° C until it achieves a moisture content lower than 12%. Afterwards it is cooled, sieved and packaged. Because pepper is hygroscopic, it must be packaged quickly after processing using a material that serves as a barrier to moisture.

The moisture content of the final product should range between 5% and 12% to prevent the proliferation of fungi.

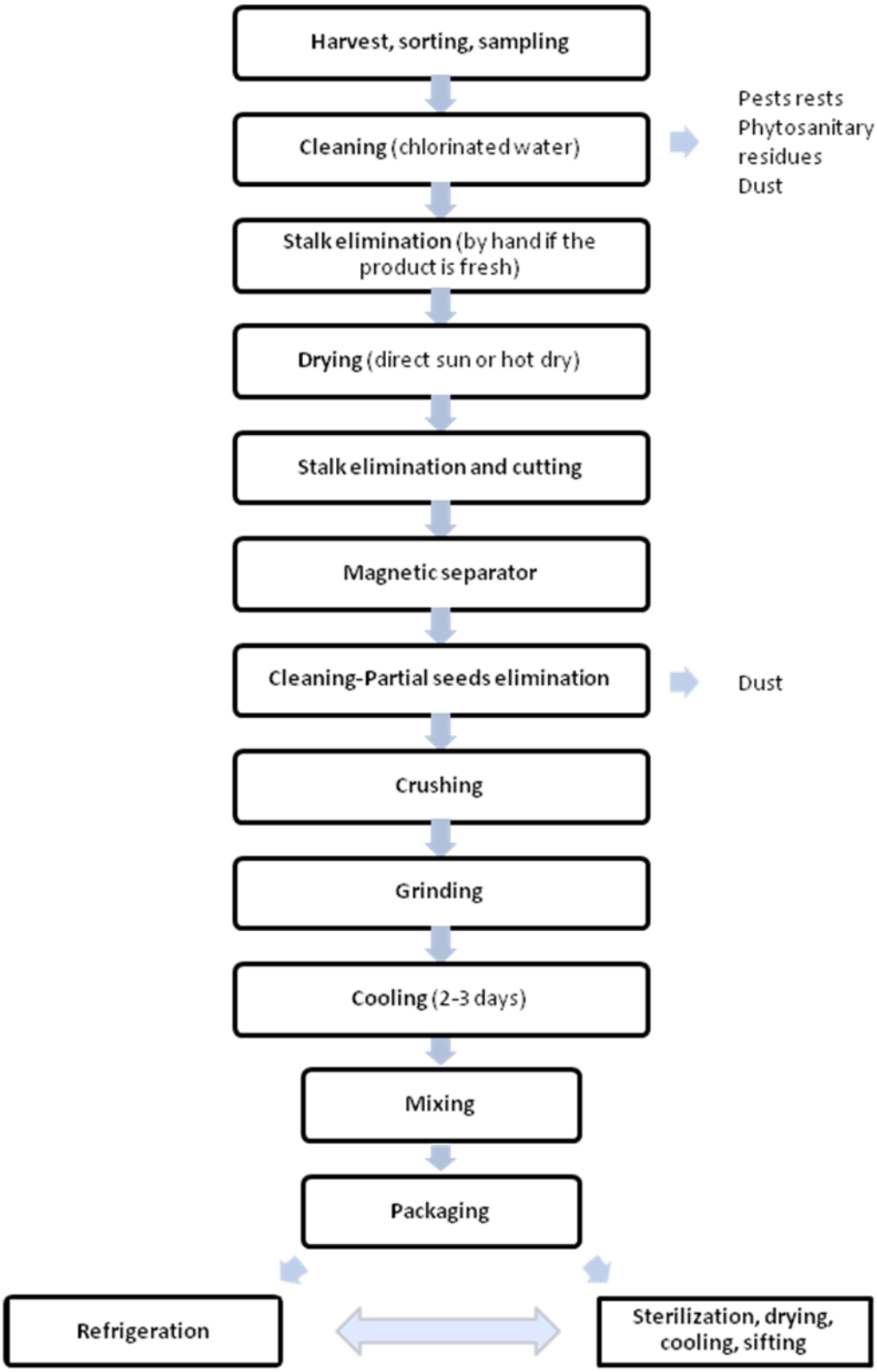
4.6 STORAGE

The layout, design, construction, location and size of pepper storage areas should permit adequate maintenance, cleaning and/or disinfection.

When necessary, these areas should provide suitable conditions for handling and storage at controlled temperature and a sufficient capacity for maintaining foodstuffs at appropriate temperatures that can be monitored and, if necessary, recorded. The atmosphere should be maintained at a relative humidity of 55 to 60 per cent to protect the quality and prevent mold growth.

KEY POINTS TO AVOID OTA CONTAMINATION IN PAPRIKA:

- **Prevention of fruit contamination on the plant**
- **Fruit selection, discarding completely the damaged peppers throughout the entire process**
- **Fruit drying without direct contact with the ground**
- **Hygiene, moisture and temperature control from the field to the consumer**


Harvest, sorting, sampling
Cleaning (chlorinated water)
Pests rests
Phytosanitary residues
Dust
Stalk elimination (by hand if the product is fresh)
Drying (direct sun or hot dry)
Stalk elimination and cutting
Magnetic separator
Cleaning-Partial seeds elimination
Dust
Crushing
Grinding
Cooling (2-3 days)
Mixing
Packaging
Refrigeration
Sterilization, drying, cooling, sifting

Notes on the flow chart:

• The process of stalk elimination is optional. Virtually all traded paprika comes from the full grinding of pepper with the stem attached.

• The seeds elimination process is also optional.

• Cooling only applies in the case of milling with traditional stone mills, less and less used. The modern impact grinding mill does not heat the product, so that the cooling step is not necessary.

• The ground paprika is recommended to be finally stored under refrigeration conditions in order preserve the color, but it is usually stored at room temperature.

ANNEX 3: PROJECT DOCUMENT

SUBMITTED BY SPAIN

PROJECT DOCUMENT

PROPOSAL FOR A "CODE OF PRACTICE FOR THE PREVENTION AND REDUCTION OF MYCOTOXINS IN SPICES"

1- Purpose and Scope of the new work

The purpose of the proposed new work is to provide to member countries and the food and feed producing industries a guidance to prevent and reduce mycotoxin contamination of spices. The Code will cover different types of management practices for control mycotoxins in different spices.

2- Relevance and timeliness

Several mycotoxins have been evaluated by the International Agency for Research on Cancer (IARC). Aflatoxins have been classified as Group 1 (carcinogenic to humans) while OTA has been clasified as Group 2B (possible human carcinogen).

Mycotoxins are fungal secondary metabolites that have been associated with severe toxic effects to vertebrates. They are produced by many important phytopathogenic and food spoilage fungi including Aspergillus, Penicillium, Fusarium, and Alternaria species. The contamination of foods and animal feeds with mycotoxins is a worldwide problem.

Human exposure to mycotoxins may can be high due to the fact that they are present in a wide variety of foodstuffs, such as spices, cereals, oilseeds, some fruits and vegetables, nuts, coffee, wine, etc. Besides their presence in food, they are stable compounds and therefore they cannot be removed completely from those foodstuffs. Thus, it is important to maintain the level contamination of mycotoxins in food at the lowest achievable level (ALARA principle).

It was recognized by FAO that the most efficient way to approach the problem of mycotoxins contamination in foodstuffs is the prevention or minimizing their concentrations by means of following a code of good practice.

3- Main aspects to be covered

The proposed new work will focus on good practices that will prevent or reduce contamination of spices with mycotoxins. The code will cover Good Agricultural Practices, Good Manufacturing Practices and Good Storage practices, since mycotoxin contamination can develop during any of this steps.

4- Assessment against the criteria for the establishment of work priorities

a) Consumer protection from the point of view of health, food safety, ensuring fair practice in the food trade and taking into account the identified needs of the developing countries.

The code will provide additional guidance for countries in order to preventing and reducing mycotoxins contamination of spices and consequently minimize consumer dietary exposure to mycotoxins.

b) Diversification of national legislations and apparent resultant or potential impediments to international trade.

The code would provide internationally recognized scientific and technical guidance in order to improve the enhancement of international trade.

c) Work already undertaken by other organizations in this field

There are some practical recommendations to avoid mycotoxin producing moulds during harvest and processing of several spices in the FAO Diversification Booklet 20 on Spices and herbs for home and market.

5- Relevance to Codex Strategic Goals

The work proposed falls under all five Codex Strategic Goals:

Goal 1: Promoting Sound Regulatory Frameworks

The result of this work will assist in promoting sound regulatory frameworks in international trade by using scientific knowledge and practical experience for prevention and reduction of mycotoxins contamination of spices.

This work will harmonize procedures for developed and developing countries with a view to promoting maximum application of Codex Standards for fair trade.

Goal 2: Promoting widest and consistent application of scientific principles and risk analysis.

This work will help in establishing risk management options and strategies to control mycotoxins in spices.

Goal 3: Strengthening Codex work-management capabilities

By establishing a general framework for the management of food safety risks associated with the prevention and reduction of mycotoxins contamination of spices will provide a general document that can be referenced by CCCF and it can be used by many countries.

Goal 4: Promoting cooperation between seamless linkages between Codex and other multilateral bodies.

The work will supplement the information already provided by FAO on moulds control measures and thus contribute to FAO's work.

Goal 5: Promoting maximum application of codex standards

Due to the international nature of this problem, this work will support and embrace all aspects of this objective by requiring participation of both developed and developing countries to conduct the work.

6- Information on the relationship between the proposal and other existing Codex documents

This new work is recommended in the Discussion Paper on the feasibility of a code of practice for prevention and reduction of mycotoxins in spices (CX/CF 15/9/16).

The Codex Code of hygienic practice for spices and dried aromatic plants (CAC, 1995) contains general provisions to prevent mycotoxin contamination in spices, such as certain precautions to be utilized during the drying process and the inclusion of the mycotoxin control of the raw material. This Codex COP has been amended recently by the Committee on Food Hygiene (CCFH, 2013) taking into account the COP approved by Spain and has been adopted by the Codex Alimentarius Commission (CAC, 2014).

7- Identification of any requirement for and availability of expert scientific advice

Mycotoxins have been assessed by JECFA on several occasions and aflatoxins is currently present on the Priority List for Evaluation by JECFA. The outcome will give further evidence on the effectivity of management practices for the control of mycotoxins contamination of food and feed.

8- Identification of any need for technical input to the standard from external bodies

Currently, there is no need for additional technical input from external bodies.

9- The proposed timeline for completion of the new work, including the starting date, proposed date of adoption at Step 5 and the proposed date for the adoption by the Commission, the timeframe for developing a standard should not normally exceed 5 years.

If the Commission approves, the draft Code of Practice will be circulated for comments at Step 3 and consideration by the 10th session of CCCF at Step 4 in 2016. Adoption at Step 5 by the Commission is planned for 2017 and adoption at Step 8 by the Commission is foreseen for 2018.

ANNEX 4: PARTICIPANTS LIST

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