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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

WORLD HEALTH ORGANIZATION

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Agenda Item 16b **CX/FAC 00/17**

January 2000

JOINT FAO/WHO FOOD STANDARDS PROGRAMME

CODEX COMMITTEE ON FOOD ADDITIVES AND CONTAMINANTS
Thirty-second Session
Beijing, People's Republic of China, 20-24 March 2000

PROPOSED DRAFT CODE OF PRACTICE FOR THE PREVENTION OF CONTAMINATION BY OCHRATOXIN A IN CEREALS

(Prepared by Sweden)

BACKGROUND

1. The 31st CCFAC proposed the elaboration of this Code under the direction of Sweden with assistance provided by Argentina, the Netherlands, the United Kingdom, Canada and the United States (ALINORM 99/12A, para. 106). The 23rd Session of the Commission approved the proposed draft Code of Practice for the Prevention of Contamination by Ochratoxin A in Cereals as new work (ALINORM 99/37, Appendix VIII).

2. Due to time constraints, it has not been possible for the above mentioned member states to give any extended consideration to this first version of the document.

INTRODUCTION

3. Ochratoxin A is a mycotoxin of considerable concern for human health and is classified as a possible human carcinogen (1). Normally correspond to 50-80% of average consumer intake is derived from cereals (2-3). Consequently, prevention of Ochratoxin A formation by specific moulds in cereals would have a significant impact on levels of human exposure.

4. A large number of fungal species have been reported to produce Ochratoxin A, especially in the genera *Penicillium* and *Aspergillus*. Despite this, it has only been convincingly reported that *Penicillium verrucosum*; two species in *Aspergillus* section *Nigri* and four species in section *Circumdati* (formerly the *Aspergillus ochraceus* group) produce Ochratoxin A (4). Of these fungi, only *Penicillium verrucosum* is known to be consistently associated with cereals, but this has only been thoroughly studied in the Nordic countries.

5. Strains producing ochratoxin A were originally referred to as P. *viridicatum*, but it was later regarded as a distinct species and was provisionally called "*P. viridicatum o-c*" (or group II and III) (5, 6). In 1985 it was formally proposed that the name *P. verrucosum* should be used for these two groups (7). This was later confirmed by others (8).

6. *P. verrucosum* is a psychrotolerant species and, even though it has been found in refrigerated sausages in Italy and Spain, it may not be expected to thrive on cereals in subtropical or tropical climates. Ochratoxin A production by black *Aspergillus* species has been reported by at least four independent groups and so has Ochratoxin A production by *A. ochraceus* and related species. Thus these species are likely candidates for Ochratoxin A production in cereals in warmer regions. On the other hand, these black and

ochre coloured aspergilli have usually been associated with coffee, grapes, spices, and much more infrequently, with cereals. However, a strong correlation between Ochratoxin A in rice and an unidentified *Aspergillus* species has been reported (9).

7. Stored cereals may be invaded by storage fungi, like *P. verrucosum*, when they are not properly dried or growth may start from locally-moistened areas. Surveys from countries with a temperate climate, where *P. verrucosum* is the most important Ochratoxin A producer, indicate that the problem of Ochratoxin A contamination is mainly associated with the post-harvest conditions (10-13). There is less information on Ochratoxin A production by *Aspergillus* species in warmer climates, e.g. whether the infection and toxin production starts already in the field on the growing plant.

8. The dominating preservation method for cereals is drying. Heated-air dryers seems to be the dominating method in Northern Europe, although cold-air dryers are not uncommon. Other preservation methods, used for grain intended for feed, are acid-preservation and airtight storage. In a Swedish investigation, *Penicillium verrucosum* and Ochratoxin A were most frequent in grain dried with ambient air. The investigation revealed that the common faults during handling and preservation of grain are low fan capacity in near ambient dryers and low drying capacity in heated air dryers, lack of moisture meters, perforations in sealed silos and defective alarm units on applicators for propionic acid (13).

9. If storage conditions support fungal activity, species of *Eurotium*, *Aspergillus* and *Penicillium* often occur. *Eurotium* and *Aspergillus* species are most tolerant to towards dry storage conditions and the minimum moisture content for growth is about 14-15% in small grain (wheat, oats, rye and barley) when the temperature is 20-35°C. *Penicillium* species need higher moisture contents to grow, and the minimum moisture content for growth of *P. verrucosum* is 16-17%. For ochratoxin A production the moisture content needs to be approximately 1% higher (13). Another study showed that grain stored with localised moisture levels of 16.3% and above in barley, and 17.3% and above in wheat, is potentially at risk from ochratoxin A contamination (14).

10. Practices that reduce ochratoxin A contamination in the field and after harvest may differ between climate regions and different cereal crops. However, general measures to avoid fungal infection of crop in the field and after harvest, such as those described in ALINORM 97/12A, appendix IX, would also applicable to reduce ochratoxin A contamination (15-16).

11. The recommendations for reducing ochratoxin A contamination in raw cereals in the present document are divided in two parts:

I) Recommended practises based on Good Agricultural Practice (GAP)
II) Suggestion for future management systems based on Hazard Analysis Critical Control Points (HACCP).

I. RECOMMENDED PRACTICES BASED ON GAP

PREHARVEST

12. An important step in preventing infection with mycotoxin-producing fungi in the field is to reduce the sources of inoculum as far as possible. Prepare the seed bed for new crop by destroying or removing old seed heads or other suitable substrates for growth of ochratoxin-producing fungi.

13. Utilise soil tests if possible to determine fertiliser needs and apply fertiliser and soil conditioners to assure adequate soil pH and plant nutrition to avoid plant stress, especially during seed development.

14. As far as practical, sow and harvest crops at times which will avoid high temperature and drought stress during the period of seed development and maturation.

15. Minimise insect damage and fungal infection by proper use of appropriate approved insecticides and fungicides and other appropriate practices within an integrated pest management program.

16. Avoid overcrowding of plants by sowing at the recommended row and intra-plant spacing for the species/varieties grown.

17. Maintain a weed-free environment in the growing crop by use of appropriate approved herbicides and other suitable cultural practices.

18. Eliminate fungal vectors in the vicinity of the crop and use proper crop rotation

19. Minimise mechanical damage to crops during cultivation.

20. Irrigation is a valuable method of reducing plant stress in some growing situations. If irrigation is used, ensure that it is applied evenly and that all plants in the field have an adequate supply of water.

21. Make sure in good time before harvest that all equipment, which is used for the harvesting and preservation of the cereals, is functioning. A breakdown during the critical time of processing may cause quality losses and eventually mycotoxin formation. Keep important spare parts available at the farm to ensure repairing without time losses. Make sure that equipment for moisture content measurements is calibrated.

22. Practice good sanitation for storage structures, wagons, elevators and other containers to minimise the risk that the crops will be contaminated. If the previous stored crops been heavily infected by moulds, it is recommended to apply a chemical sanitation.

HARVEST

23. Harvest grain at full maturity unless allowing the crop to continue to full maturity would subject it to extreme heat, rainfall or drought conditions.

24. As far as possible, avoid mechanical damage and contact with soil during harvesting.

PRESERVATION

25. Dry the grain to a moisture content corresponding to a water activity of less than 0.70 (less than 14% moisture content in small grain) as quickly as possible. To avoid ochratoxin A formation, start the drying process immediately after harvest and preferably use heated-air drying. In the temperate climate region, when intermediate or buffer storage is necessary because of on low drying capacity, make sure that the moisture content is less than 16%, that the storage time is less than 10 days, and the temperature is less than 20°.

26. Measure the moisture content of the grain before and after drying. This will give information on necessary drying time and if the grain is dried enough for storage. Note that it is necessary to check the moisture content in several spots of each load of the harvest grain since the moisture content may vary considerably within the same field. In addition, measurements after drying must be performed in a representative way to check the variation in moisture content within the lot. In a heated-air dryer the sampling may be performed repeatedly in the stream when the grain has passed the elevator and been mixed. To reduce the variation of moisture content within the lot, the grain may be moved to another silo after the drying process.

27. Document the preservation processing and storage by making notes of measurements, procedures deviating from the normal processing, etc. Such notes are very valuable to clarify the cause of mould growth and mycotoxin formation and to avoid similar mistakes in the future.

STORAGE

28. Make sure that the storage conditions include dry, well ventilated structures that provide protection from rain or seepage of ground water, and minimum temperature fluctuations.

29. For bagged commodities, ensure that bags are clean and dry and stacked on pallets.

30. Ensure that the grain is free of mould growth and insects and prevent access by rodents and birds during storage.

31. Store at as low temperature as possible. Where possible, aerate the grain to maintain proper temperature and moisture. Check moisture content in the stored grain at intervals during the storage period.

32. Monitoring of temperature during storage may reveal mould growth. Measuring of the temperature should be done at several fixed points in the stored grain. A temperature rise of 2-3°C may indicate microbial growth. Separate the infected part of the grain and send samples for analysis. Avoid using infected grain for food or feed production.

TRANSPORT

33. Make sure that transport containers and vehicles are free of mould, insects and any contaminated material by thoroughly cleaning before use or re-use. Periodic disinfestation with appropriate approved fumigants or other pesticides may be useful.

34. Protect shipments of grain from re-moistening by appropriate means. Avoid measures that may cause sweating of the grain, which could lead to local moisture build up and consequent mould growth and mycotoxin formation.

35. Avoid insect and rodent infestation during transport by use of insect-resistant containers or insect and rodent repellent chemical treatments.

II. OCHRATOXIN A MANAGEMENT SYSTEM BASED ON HAZARD ANALYSIS CRITICAL CONTROL POINTS (HACCP)

36. At the Third International Conference on Mycotoxins, which took place in Tunisia in March 1999, one of the general recommendations was that integrated mycotoxin control programmes should incorporate HACCP principles in the control of risks associated with mycotoxin contamination of foods and feeds (17).

37. HACCP is a food safety management system that is used to identify and control hazards within the production and processing system. The general principles of HACCP have been described in several documents (18-19) and FAO/IAEA will publish a HACCP manual for mycotoxin control in the near future. Briefly, an ochratoxin A management system would include the following basic principles:

1. Identification of hazards and control measures

The hazards (in this case ochratoxin A) and the risk associated with the hazard is identified and assessed at each step in the agricultural and/or processing system. Possible control measures are described.

2. Identification of the critical control points (CCP) for ochratoxin A formation during cereal production

An ochratoxin A management system based on the HACCP approach must consider hazards at all stages of the production, handling and processing (pre-harvest, harvest and post-harvest). In addition, a prerequisite to the development of a HACCP program is the observance of good agricultural practice (GAP) and good manufacturing practice (GMP). In an integrated mycotoxin management incorporating the HACCP concept, each identified and appropriately managed phase will help prevent the risk of exposure to the toxin.

3. Establishment of critical limits for all Critical Control Points

A CCP may be a raw material, a location, a practice, a procedure or a process stage, but it must be specific. The critical limit (for example a temperature or a water activity) is the value that separates acceptability from unacceptability for each CCP.

4. Establishment of monitoring systems

A monitoring system, which gathers information about each raw material and process stage, must be established to ensure that the process operates under control, that is, that the criteria is met. Monitoring methods should be rapid to be effective.

5. Establishment of corrective action in the event of deviation of a critical limit

There are two types of corrective actions. The first action is to regain control and the second type of corrective action may be scouring or other physical methods, which needs to be carried out to ensure that ochratoxin A contaminated grain does not enter the food chain.

6. Verification of the system

The verification provide additional information to reassure that the application of HACCP results in the production of safe food

7. Record keeping

Record keeping is an essential part of the HACCP. This ensures that all information, which has been gathered during installation and operation of the system, will be readily accessible.

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