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Viale delle Terme di Caracalla, 00153 Rome, Italy - Tel: (+39) 06 57051 - E-mail: codex@fao.org - www.codexalimentarius.org

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DISCUSSION PAPER ON AN ANNEX FOR ERGOT AND ERGOT ALKALOIDS TO THE CODE OF PRACTICE FOR THE PREVENTION AND REDUCTION OF MYCOTOXIN CONTAMINATION IN CEREALS (CAC/RCP 51-2003)

(Prepared by Germany)

Codex Members and Observers are kindly invited to consider the conclusions and recommendations in paragraphs XX while taking into account the information and data provided in the discussion paper, general the provisions in the Code of Practice for the Prevention and Reduction of Mycotoxin Contamination in Cereals (CAC/RCP 51-2003) (Item 9) and the provisions in the various Annexes specific for certain mycotoxins in cereals (Item 10) in order to assist CCCF in deciding on the need for a specific Annex on ergot and ergot alkaloids CAC/RCP 51-2003.

BACKGROUND

1. The 9th Session of the Committee on Contaminants in Foods (March 2015) agreed to develop a discussion paper on a possible extension of the *Code of Practice for the Prevention and Reduction of Mycotoxin Contamination in Cereals (CAC/RCP 51-2003)* as regards developing a new Annex on the prevention and reduction of contamination by ergot and ergot alkaloids in cereal grains.[1]

2. Noting that the proposal to add this annex was made by Germany in the eWG that worked on *the revision of the Code of Practice for the Prevention and Reduction of Mycotoxin Contamination in Cereals* Germany agreed to present a discussion paper and an outline of an Annex on ergot and ergot alkaloids for inclusion in the aforesaid Code of Practice.

INTRODUCTION

3. “Ergot” is the term used for the solidified mycelium of the fungus *Claviceps purpurea*, *africana, fusiformis, sorghi* and related species, which can afflict grasses and cereals of all kinds and may contain ergot alkaloids. A dark, sometimes white ergot (sclerotium) is formed instead of a grain in the ears of cereal infected via the plant’s blossom. These bodies usually differ significantly from the cereal as an overall entity in terms of their shape, colour and composition.

4. The main types of cereal affected are rye and triticale (*Claviceps purpurea*), sorghum (*Claviceps africana, sorghi, sorghicola*) and pearl millet (*Claviceps fusiformis*). In spring seasons with longer moist and cool periods, wheat and barley might also be affected. A contamination of the harvested product with ergot and the toxic compounds – ergot alkaloids (EA) – can occur.

5. Out of 40 known ergot alkaloids the most relevant are ergocornine, ergocristine, ergocryptine, ergometrine, ergosine, ergotamine and their epimers. Moreover, in sorghum ergot also dihydro-ergosine and related alkaloids are relevant components (Blaney et al. 2010). Sclerotia contain different amounts of EAs, depending on the fungi species, the host, the weather conditions and the geographical region (Lorenz 1979). The total alkaloid content in a single sclerotium varies and can reach up to 0.5%. A total ergot alkaloid mean of 0.08% in ergot bodies has been reported based on European data (EFSA 2012).

[1] REP15/CF, paras 103-104

6. Intoxication induced by ergot alkaloids is commonly known as ergotism or “St. Anthony’s fire”, which was ubiquitous in the middle Ages. Local epidemics have occurred also in more recent years in France (Fuller 1968), India (Bhat et al. 1976) and Ethiopia (Demeke et al. 1979), respectively. There are two symptomatic forms of ergotism: gangrenous and convulsive. In the gangrenous form, tingling effects are felt in peripheral tissues finally leading to the loss of limbs, whereas in convulsive ergotism the tingling is followed by hallucinations, delirium and epileptic-type seizures.

7. The Federal Institute of Risk Assessment in Germany (BfR) wrote in FAQs on ergot alkaloids in cereal products: “Following oral ingestion of small quantities of ergot alkaloids, acute symptoms such as vomiting, spasms, headaches, cardiovascular problems (e.g. hypertension or cardiac arrhythmia) and dysfunctions of the central nervous system can occur. Human data show that uterus contractions can be caused even by small intake quantities. These can in turn lead to uterus bleeding and miscarriage. Following consumption of high ergot alkaloid quantities, acute toxic effects such as circulatory disorders due to the vaso-constrictive effects on blood vessels, especially to the cardiac muscle but also to the kidneys and the extremities have been described. The symptoms can be accompanied by hallucinations, spasms and impaired sensations and paralysis and can, following respiratory or cardiac arrest, lead to death.”

8. “Chronic intake of moderate quantities of ergot alkaloid can have a negative impact on reproduction (e.g. trigger miscarriage, lower birth weight, deficient lactation). Chronic oral ingestion of large quantities of ergot alkaloids result in symptoms which correspond to acute ingestion of high quantities of ergot alkaloids. This is known from observations of unwanted effects where certain ergot alkaloids were used as active ingredients in medicines or where, following ingestion of cereal products containing high levels of ergot, people became ill.” Available under http://www.bfr.bund.de/en/a-z_index/mycotoxins-130447.html accessed on Nov 24th, 2015.

9. In 2012, the European Food Safety Authority (EFSA) established the following values for the group tolerable daily intake quantity of ergot alkaloids - 0.6 micrograms per kg of body weight and per day, and 1 microgram per kg of body weight for the group acute reference dose (EFSA 2012). These values were confirmed by Germany’s Federal Institute for Risk Assessment (BfR 2013).

10. In addition, in its current assessment of individual cases, the BfR concludes that, in the light of the data considered with regard to the incidence of ergot and ergot alkaloids in Germany, undesirable effects on individuals’ health are possible for certain groups of consumers (toddlers and pregnant women) eating baked products and flour that contains ergot alkaloids (BfR 2013).

11. The assessment revealed a potential risk for consumers eating greater portions of contaminated cereal based products with levels exceeding 64 µg ergot alkaloids in one kg of product (BfR 2013). Moreover, ergot alkaloids contents are believed to remain constant during processing (Fajardo 2012). Thus, the level of 64 µg/kg is achievable if the initial amount of ergot alkaloids in cereals or flours is low, lying between 100 and 250 µg/kg depending on the product recipe.

12. At a first step the European Commission established a maximum level (ML) of 0.5 g ergot sclerotia in one kg of unprocessed cereals placed on the market for first-stage processing of cereals except corn and rice (EC 2015). The maximum level may be extending to a ML on ergot alkaloids in the future after gathering more data on EA content in processed cereals, where ergot sclerotia is invisible.

13. Moreover, contamination with ergot alkaloids is also an important feed-related problem (Bennet & Klich 2003, EFSA 2005), e.g. cattle, sheep and poultry are sensitive to ergot toxins. Therefore maximum levels in feed have been established in different countries e.g. in Canada (CFIA), in the EU (EC 2002) or many others.

14. Ergot bodies remaining on the field at surface level can germinate very much better and more quickly than ergot that is worked into the soil deeper than 5 cm (Bretag & Merriman 1981). Especially after rye or triticale has been planted, the soil should be ploughed since not using a plough might imply that the ergot remains on the soil’s surface and can germinate easily in the next spring to primary infect the crop.

15. All varieties can be contaminated by ergot if the conditions favour infection. Among the rye varieties the degree of susceptibility to ergot correlates with the discharge of pollen (Miedaner et al. 2010). A high pollen count increases the likelihood of fertilisation, meaning that the blossom closes more quickly and that ergot spores and conidia are rejected. A competition between pollen and fungi spores has been reported for sorghum as well (Cisneros-Lopez 2010). In the case of hybrid varieties with a lower level of pollen discharge, the pollen count can be raised by admixing population varieties; susceptibility to ergot can thereby be reduced. Usually population varieties discharge pollen more powerfully and over a longer period than hybrid sorts do, whereas hybrid varieties bloom more briefly and more compactly. In principle, the choice of variety should be appropriate to the given location taking weather specifies into account (Workneh & Rush 2006, Hackauf et al. 2009).

16. Alongside primary infection by ergot spores, secondary infection can take place via honeydew discharged by blossoms already infected (Wood & Coley-Smith 1982). Often it is inferior grasses, growing either in the main body of the crop or at its margin, that transmit secondary ergot infections (Bayles et al. 2009). The challenge is to avoid these host plants consistently. It is also important to pre-empt the development of late-bolting plants (not enough pollen may be available for quick fertilisation), e.g. by laying sufficiently wide tramlines for agricultural vehicles (Bailey et al. 2003).

17. Unfavourably-located sections in a field, e.g. edges of the field, where flowering has been uneven, or depressions (areas of dewy ground) tending to have a more moist climate, can be affected by ergot more severely than other sections of a land-plot. If certain parts of a plot are more strongly afflicted by ergot, these areas should be threshed separately during harvesting. This part of the crop should be excluded from the food-processing chain.

18. Ergot bodies have a softer, greasier and less dense structure than the grain kernels. There is a high probability that very fine ergot dust can be released via rubbing of the kernels and the sclerotia against each other when moving the lot containing ergot bodies. The rubbed-off material has highly-adhesive properties such that it sticks to the grain surface. In addition, breakage of the sclerotia can occur very easily, also triggering very fine ergot dust. This dust can deposit itself on the grain's surface, in the stomach furrow and in the beard of the grain. Since this effect is invisible, it is important to apply avoidance strategies and to combat the resulting ergot alkaloid contamination of the cereal.

19. Cleaning should remove ergot bodies and dust from the consignment of cereal to the greatest possible degree. Practical experiences show that this is achievable by a combined use of different cleaning principles and systems, e.g. mechanical light-fraction separators, sieve separators, trieurs, table separators, spiral separators, optic-electronic separators or colour-based optical sorting systems. If there is a high level of ergot, the throughput capacity of the cleaning diagram should be adapted so as to attain effectiveness and a continuous process control is required. The alternative to ensure this at individual enterprise level would be a second cleaning process for the pre-cleaned grain. The adhering dust on the grain surface can be removed by cleaning the surface of the kernels e.g. via scrubbing, brushing or peeling. Special attention has to be put on the grain furrow as this part of the kernel usually carries a lot of dirt and unwanted substances. This part of the kernel can be cleaned with a crusher. In general, the dust and the fine filter flours, which may contain higher content of ergot alkaloid, should be removed via a suction ventilator and an effective filter system.

20. Brief overviews of the issue can be found among others e.g. in Lorenz 1979 (disease and outbreaks), Haarmann et al. 2009 (update review on plant diseases), Menzies and Turkington 2015 (life cycle and management of ergot), Bayles et al. 2009 (whole farm approach), Miedaner and Geiger 2015 (genetic variation of cultivars), Malysheva et al. 2014 (occurrence in cereal and cereal products), Merkel et al. 2012 (baking and digestion).

CONCLUSIONS

21. There is a need to address ergot /ergot alkaloid contamination in the general Code of Practice (COP) for the Prevention and Reduction of Mycotoxin Contamination in Cereals.

22. The main points identified with regard to safety concerns are

a. Health related issues associated with these ergot toxins in cereals are known since the middle ages and have recently been assessed conscientiously.
b. Some of the substances are well known since they are used as drugs for medical treatment.
c. A group tolerable daily intake (TDI) and a group acute reference doses (ARfD) value have been defined.
d. Acute and chronic intake of higher amounts can have unwanted effects.
e. The (German) risk assessment revealed a potential risk for certain consumer groups eating higher amounts of contaminated cereals or cereal products.

23. The prevention of contamination with these mycotoxins is not fully covered by the general provisions of the COP,

a. The ways of infection are in some cases different from other Fungi species. For example a second infection can occur via the honeydew of infected grasses, growing either at the edge of the field or within the crop,
b. Management practices of the crop differs at some points from management of other fungi infections,
c. Unlike other mycotoxins, which are solely carried on the kernel of the cereals, ergot bodies contain the toxins and are carried as visible structures within the lot and
d. Physical properties are different between the ergot bodies and the grain kernels.

24. A different sampling plan and a different method of assessing the level of contamination, such as e.g. sclerotia count, may be considered. In addition, it has to be taken into account that ergot containing dust can invisibly contaminate the cereal too.

25. Consequently ergot bodies and the fine ergot dust (which can invisibly stick on the grains surface and in the furrow) have to be avoided and removed from the processing chain.

26. Therefore there is a need for a specific annex to address those safety key points that are not covered by the general provisions of the COP.

RECOMMENDATION

27. It is recommended that CCCF agrees on the need for an Annex on ergot and ergot alkaloids in the Code of Practice for the Prevention and Reduction of Mycotoxin Contamination in Cereals (CAC/RCP 51-2003) and that the proposed Annex provided in the Appendix could serve as the basis for discussion in the Committee.

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APPENDIX

ANNEX 6

PREVENTION AND REDUCTION OF CONTAMINATION BY ERGOT AND ERGOT ALKALOIDS IN CEREAL GRAINS

RECOMMENDED PRACTICES BASED ON GOOD AGRICULTURAL PRACTICE (GAP) AND GOOD MANUFACTURING PRACTICE (GMP)

1. Good Agricultural Practice includes methods to reduce Claviceps fungal infection and ergot alkaloid contamination in cereals in the field and during planting, harvest, storage, transport and processing.

Planting

2. Refer to paragraphs 11-16 in the General Code of Practice.
3. Work the soil by turning it over, when the preceding crop (in the rotation) has been infected by ergot; as far as is possible, the working of the soil should involve use of a plough. For cases in which the soil is worked without using a plough, the incision into the soil should be deeper than 5 cm.
4. When cultivating varieties with higher susceptibility to ergot, admixture of population varieties is an option to consider. Take into account the climate conditions of the given location.
5. Select the thickness and depth of seed, distances between rows, the density of sown material, fertiliser and use of growth regulator, on the basis of adapting to the specific situation, so as to attain an even and rapid blossoming of the crop and to avoid late-bolting plants.
6. Lay sufficiently wide tramlines for agricultural vehicles.
7. Combat inferior grasses within the cereal under cultivation and also employ a higher level of crop hygiene at the field's edge: ensure effective care of the margin; combat host plants by cutting them before blossoming of the crop.

Pre-harvest

10. Refer to paragraphs 17-22 in the General Code of Practice.
11. Consider a partial harvesting of the crop as an option: separately thresh field/subsections with a high incidence of ergot, in a way that is safe for humans and animals.

Harvest

13. Refer to paragraphs 23-26 in the General Code of Practice.
14. There should be an air-stream cleaning during the harvest so as to remove ergots and infected dust.
15. Remove materials detached in cleaning, and also cereal dust, in good order and according to established professional practice; eliminate them in a way that takes them out of the processing chain of activities.

Drying and Processing at Farm Level

16. Refer to paragraphs 27-32 in the General Code of Practice.
17. Avoid movement of a product consignment contaminated by ergot; there is a major danger of rub-off and also of adhesive particles of ergot dust. Eliminate all dust particles in each stage of the value-added chain in such a way that they are withdrawn before the next stage in the processing chain.

Storage

18. Refer to paragraphs 33-42 in the General Code of Practice.

Transport from storage

19. Refer to paragraphs 43-45 in the General Code of Practice.

Processing

20. Refer to paragraphs 46-53 in the General Code of Practice.
21. Carry out "white cleaning" process (scrubbing, brushing or peeling). Eliminate and dispose of rubbed-off material and also dust generated from taking receipt of the product and from cleaning activities.
22. Check the filter dust in the crusher area and consider the option of removing it from the mill unit, as an additional measure for reducing levels of ergot alkaloid content.