CODEX ALIMENTARIUS COMMISSION

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Food and Agriculture Organization of the United Nations

World Health Organization

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CODEX COMMITTEE ON CONTAMINANTS IN FOODS

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DISCUSSION PAPER ON REVIEW OF THE *CODE OF PRACTICE FOR THE REDUCTION OF AFLATOXIN B1 IN RAW MATERIALS AND SUPPLEMENTAL FEEDINGSTUFFS FOR MILK-PRODUCING ANIMALS* (CXC 45-1997)

(Prepared by the Electronic Working Group chaired by Canada and co-chaired by Saudi Arabia)

Codex members and observers wishing to submit comments on the recommendations for the revision of the *Code of practice for the reduction of aflatoxin B1 in raw materials and supplemental feedingstuffs for milk-producing animals* (CXC 45-1997) should do so as instructed in CL 2025/23-CF, available on the Codex webpage[1]

INTRODUCTION

1. The 16th Session of the Codex Committee on Contaminants in Foods (CCCF16, 2023) agreed to establish an Electronic Working Group (EWG) chaired by Canada to develop a discussion paper on the review of the *Code of practice for the reduction of aflatoxin B1 in raw materials and supplemental feedingstuffs for milk-producing animals* (CXC 45-1997).[2] A number of member countries or observer organizations recommended this code of practice (CoP) for inclusion in the *Overall Highest Priority List (OHPL) of Codex Standards and Related Texts for Contaminants in Food and Feed* based on meeting various prioritization criteria, including:[3]

   (i) Included in List A.1 (the CoP was established ≥25 years ago, i.e. in 1997)

   (ii) Health-based guidance value cannot be established (aflatoxin M_1 is a genotoxic carcinogen)

   (iii) Milk is a staple food

   (iv) Milk is consumed by people in developing countries

   (v) CXC 51-2003[4] was drafted and updated without review of CXC 45-1997

2. At CCCF17 (2024), the EWG Chair presented the new and updated information on aflatoxin prevention and reduction measures in animal feed, noted other sections (e.g. scope, definitions) that could potentially be added to CXC 45-1997 and also highlighted areas of overlap with the Codex CoPs for aflatoxins in cereals (CXC 51-2003), peanuts (CXC 55-2004) and tree nuts (CXC 59-2005), as these commodities may also be used as feed or feed ingredients. The EWG recommended revising CXC 45-1997 based on the availability of new and updated information.

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1 Codex webpage/Circular Letters: http://www.fao.org/fao-who-codexalimentarius/resources/circular-letters/en/.
Codex webpage/CCCF/Circular Letters: http://www.fao.org/fao-who-codexalimentarius/committees/committee/related-circular-letters/en/?committee=CCCF

2 REP23/CF16, para. 102 (iv) (b)

3 CF16/CRD02(Rev), Appendix II & Appendix III

4 *Code of practice for the prevention and reduction of mycotoxin contamination in cereals* (CXC 51-2003), which applies to food and feed

TERMS OF REFERENCE

3. CCCF17 agreed to re-establish the EWG, chaired by Canada and co-chaired by Saudi Arabia to:

   (i) revise the discussion paper;

   (ii) propose revisions to CXC 45-1997;

   (iii) consider how other related Codex CoPs of practice could be integrated or merged to avoid overlap, inconsistencies, and redundancies;[5] and

   (iv) prepare a project document for new work.

PARTICIPATION AND METHODOLOGY

4. A total of twenty-seven (27) Codex Members and one (1) Codex Observer (refer to Appendix VI, List of participants) registered for the EWG. Canada, as the EWG Chair, with the support of Saudi Arabia as the EWG co-Chair, reviewed the available literature on risk management practices to prevent or reduce aflatoxin B1 contamination in feed, as well as information provided by EWG members the previous year, to update CXC 45-1997.

5. Between September 2024 and January 2025, the EWG received two rounds of comments on the proposed edits to CXC 45-1997 and its associated appendices. Comments were solicited on the new technical information proposed for inclusion in the CoP, as well as the document's structure and approach to integrating related Codex texts.

6. Two (2) Codex Members provided comments during the first round, and four (4) Codex Members commented in the second round. The CoP and related appendices were revised and improved after each set of comments. They are presented in Appendices II through V of this document.

ANALYSIS OF DISCUSSIONS

7. There was general consensus by EWG members on the proposed changes relating to the technical content, structure, and integration of Codex texts by including applicable measures from the *Code of practice for the prevention and reduction of mycotoxin contamination in* cereals (CXC 51-2003) that also apply to non-cereal crops (e.g. legumes, oilseeds) and a new section on 'Related Guidance' that lists relevant Codex texts (e.g. CoPs for cereals, peanuts, and tree nuts). Certain members commented on the lengthiness of the added revisions to the CoP and recommended internal streamlining, where possible. As CXC 45-1997 was first drafted 28 years ago and has not been revised since, it includes a significant amount of expanded and new information. Efforts to streamline and avoid redundancy within and between Codex texts will continue if this is approved as new work. Greater participation from EWG members, particularly those from tropical climates, would help ensure fulsome revisions to the CoP.

CONCLUSIONS

8. The EWG supports revising CXC 45-1997 as there is sufficient new and updated information that has become available since the CoP was drafted in 1997 on aflatoxin B1 management measures in the feed of milk-producing animals. An updated CoP would therefore help more accurately and fulsomely provide practical aflatoxin B1 control measures for animal feed. An updated CoP would also aim to align with existing, more recently revised CoPs on aflatoxins in cereals and other feed ingredients and aim to avoid overlap, inconsistencies, and redundancies between Codex texts.

9. More information on aflatoxin management measures, or at least verification of the information identified to date, particularly that relating to tropical climates, would further develop CXC 45-1997. If CCCF18 approves the revision of the CoP as new work, issuing a circular letter (CL) requesting information from member countries would be helpful.

10. A project document proposing new work to revise CXC 45-1997 is presented in Appendix I. Additional documents that support this proposal for new work are also presented in the following appendices:

[5] REP24/CF17, paras. 125 and 128

(i) Appendix II: Proposed revisions to CXC 45-1997 *(for information)*

(a) New text is underlined; text proposed for removal is in strikethrough.

(b) Information from the *Code of practice for the prevention and reduction of mycotoxin contamination in* cereals (CXC 51-2003) is underlined and highlighted in yellow; in most cases, it has been shortened and paraphrased.

(ii) Appendix III: Key references consulted in drafting the proposed updates *(for information)*

(iii) Appendix IV: Voluntarily provided information on nationally approved control strategies *(for information)*

(iv) Appendix V: National regulations for aflatoxin B_1 in animal feed *(for information)*

11. To address the request by CCCF17 to consider how related Codex CoPs could be integrated or merged to avoid overlap, inconsistencies, and redundancies, the EWG supports including the following in CXC 45-1997:

(i) Applicable measures relating to cereals from the *Code of practice for the prevention and reduction of mycotoxin contamination in* cereals (CXC 51-2003) that also apply to non-cereal crops.

(ii) A new 'Related Guidance' section that lists relevant Codex CoPs and other texts.

RECOMMENDATIONS

12. CCCF is invited to consider if new work should be proposed on a revision of the *Code of practice for the reduction of aflatoxin B1 in raw materials and supplemental feedingstuffs for milk-producing animals* (CXC 45-1997) and, in the affirmative, to consider the points below:

(i) Review the project document in Appendix I and make any necessary adjustments to ensure a robust rationale is provided for the revision of the CoP in order to forward it to CAC48 (2025) for approval as new work.

(i) Review the outline for the proposed revised CoP as presented in Appendix II, in particular as to the following points to guide the EWG in further developing the CoP following approval of new work by CAC48:

(a) Whether the approach taken to consider how related Codex CoPs could be integrated or merged to avoid inconsistencies, overlaps, and redundancies is acceptable; otherwise, provide other possible approaches to take into account these texts in the revision of the CoP.

(b) Whether the proposed revisions are reasonable and if improvements could be made, e.g. addition of new sections, further development of revised sections, and whether data/information to support such revisions is available for consideration by the EWG in further developing the CoP.

Note: Risk management measures for inclusion Codex codes of practice should be readily available, applicable worldwide, and proven to be effective across different production scales, including small- and medium-sized businesses.

(ii) Consider issuing a circular letter following CCCF18 to request risk management practices and other data/ information that can support the further development of the CoP by an EWG for consideration by CCCF19 (2026).

(iii) Re-establish the EWG to further develop the CoP based on the guidance provided by CCCF, for consideration by CCCF19 (2026).

APPENDIX I

PROJECT DOCUMENT

PROPOSAL FOR NEW WORK ON THE REVISION OF THE CODE OF PRACTICE FOR THE REDUCTION OF AFLATOXIN B1 IN RAW MATERIALS AND SUPPLEMENTAL FEEDINGSTUFFS FOR MILK-PRODUCING ANIMALS (CXC 45-1997)

(For consideration by CCCF)

1. Purpose and Scope

The purpose of the proposed new work is to provide member countries and the feed industry with updated guidance to prevent and reduce aflatoxin contamination in animal feeds intended for milk-producing animals.

The scope of the new work will focus on reviewing and updating the *Code of practice for the reduction of aflatoxin B1 in raw materials and supplemental feedingstuffs for milk-producing animals* (CXC 45-1997).

2. Relevance and timeline

Aflatoxin M_1 is formed in milk as a result of aflatoxin B_1 contamination in animal feed. The *Code of practice for the reduction of aflatoxin B1 in raw materials and supplemental feedingstuffs for milk-producing animals* (CXC 45-1997) has not been revised or amended since it was first elaborated in 1997. New information has become available since 1997 on aflatoxin management in the feedingstuffs of milk-producing animals. It is important to update this CoP as milk[1] and milk products[2] continue to be staple foods worldwide, including in developing countries. Furthermore, JECFA concluded at its 56th meeting in 2002 that aflatoxin M1 is a genotoxic carcinogen.

3. Main aspects to be covered

This work will address measures to prevent or reduce aflatoxin B_1 contamination in animal feed and feed ingredients in order to mitigate aflatoxin M1 contamination of milk. All revisions will be supported by scientific data that have become available since CXC 45-1997 was elaborated in 1997.

Updates will expand upon or add new information about aflatoxin management approaches in feed and feed ingredients. It will also include current information on the use of preservatives, mycotoxin detoxifying agents and other emerging physical, biological and chemical control strategies for aflatoxins in feed.

As well, updates to CXC 45-1997 will consider how information in the Codex CoPs on aflatoxin prevention and control in cereals and, to a lesser extent, nuts and figs, can be leveraged in order to limit redundancies between Codex texts, if possible (refer to Section 6 for more information).

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

General criterion

a) Consumer protection from the point of view of health, food safety, ensuring fair practices in the food trade and taking into account the identified needs of developing countries. Milk and milk products are staple foods in many countries worldwide, including developing countries. The updated CoP will provide additional guidance for member countries and the feed industry to reduce or prevent aflatoxin contamination in feed intended for milk-producing animals, thus minimizing dietary exposure to aflatoxin M1.

A revised CoP will facilitate fair trade by making updated information on recommended practices to reduce aflatoxin contamination in the feedingstuffs of milk-producing animals available to all member countries and the feed industry. This, in turn, will support efforts to meet the Codex maximum level for aflatoxin M_1 in milks which will also facilitate trade.

Specific criteria

a) Diversification of national legislations and apparent resultant or potential impediments to international trade. The CoP would provide internationally available and recognized scientific and technical guidance that will assist in ensuring compliance with Codex and national maximum levels for aflatoxin M_1 in milk.

b) Work already undertaken by other organisations in this field. JECFA completed a risk assessment for aflatoxin M1 in 2002 at its 56th meeting.

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1 The *General standard for the use of dairy terms* (CXS 206-1999) defines milk as the normal mammary secretion of milking animals obtained from one or more milkings without either addition to it or extraction from it, intended for consumption as liquid milk or for further processing.

2 The *General standard for the use of dairy terms* (CXS 206-1999) defines a milk product as a product obtained by any processing of milk, which may contain food additives, and other ingredients functionally necessary for the processing.

5. Relevance of the Codex strategic goals

a) Goal 1: Address current, emerging and critical issues in a timely manner. Updating the CoP on the reduction of aflatoxin contamination in feeds intended for milk-producing animals will address the need for up-to-date guidance that will help ensure the health of consumers, particularly for globally relevant staple foods such as milk and milk products.

b) Goal 2: Develop standards based on science and Codex risk-analysis principles. This work will involve reviewing peer-reviewed scientific data and information that supports reducing aflatoxins in animal feed. Recommended strategies will help reduce consumer exposure to and risks posed by aflatoxin M1 in milk to meet the Codex ML for aflatoxin M1 in milks, which was supported by JECFA56's 2002 assessment of aflatoxin M_1.

c) Goal 3: Increase impact through the recognition and use of Codex standards. The proposed CoP will present a variety of recommended and scientifically proven strategies to control aflatoxin contamination in the feed of milk-producing animals that are based on current best practices and are globally available. The warm climate of many geographic regions worldwide and high humidity during storage lends itself to aflatoxin formation in feedingstuffs, making the updates to this CoP relevant to many member countries.

(d) Goal 4: Facilitate the participation of all Codex Members throughout the standard-setting process. Updates to the CoP would be conducted by an electronic working group in which all member countries will be invited to participate in. Updating an existing CoP through the Codex Step procedure will make the information on the best practices included in the CoP available to all members at each step of the process. The warm and humid climates of many regions worldwide lend itself to aflatoxin formation in feedingstuffs. As such, this work will benefit from the participation and expertise of both developed and developing countries.

(e) Goal 5: Enhance work management systems and practices that support the efficient and effective achievement of all strategic plan goals. An updated CoP will support the development and implementation of effective and efficient work management systems and practices by providing basic guidance for member countries and feed producers to reduce aflatoxin contamination in the feeds for milk-producing animals.

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

The Codex ML for aflatoxin M_1 in milks was adopted in 2001. Revisions to CXC 45-1997 will support the achievement of the Codex ML for aflatoxin M_1 in milks.

In 2003, the CAC approved the adoption of the *Code of practice for the prevention and reduction of mycotoxin contamination in cereals* (CXC 51-2003; amended 2014, 2017; revised 2016); this CoP includes aflatoxins and clearly indicates that it applies to mycotoxin prevention and reduction measures for cereal grains intended for both human and animal consumption. When first elaborated, CXC 51-2003 largely mirrored CXC 45-1997, although CXC 51-2003 has since been amended (2014, 2017) and revised (2016).

There are also Codex CoPs for aflatoxins in nuts and figs, which could be used as feed:

- *Code of practice for the prevention and reduction of aflatoxin contamination in tree nuts* (CXC 59-2005)
- *Code of practice for the prevention and reduction of aflatoxin contamination in peanuts* (CXC 55-2004)
- *Code of practice for the prevention and reduction of aflatoxin contamination in dried figs* (CXC 65- 2008)

Any future updates to CXC 45-1997 will consider if and how the other Codex CoPs for aflatoxins in other agricultural commodities could be leveraged, with a view to reducing redundancy between Codex texts, when possible.

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

JECFA56 completed a risk assessment for aflatoxin M1 in 2002. Additional expert scientific advice is not required.

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. Proposed timeline for completion of the work

Subject to approval by the CAC, work would commence in 2025, and proposed revisions to CXC 45-1997 would be presented to CCCF19 in 2026.

Given that electronic working groups were established in advance of both CCCF17 and CCCF18, and that the potential updates to this CoP were discussed at both of those meetings, it is anticipated that the final adoption of CXC 45-1997 will be in 2027.

APPENDIX II

Proposed Revisions to the Code of Practice for the reduction of aflatoxin B_1 in raw materials and supplemental feedingstuffs for milk-producing animals (CXC 45-1997)

CODE OF PRACTICE FOR THE REDUCTION OF AFLATOXIN B_1 IN FEEDS ~~RAW MATERIALS AND SUPPLEMENTAL FEEDINGSTUFFS~~ FOR MILK-PRODUCING ANIMALS

CXC 45-1997

(For information)

1. INTRODUCTION ~~Background~~

~~1.1 Aflatoxin B1 contamination of animal feedingstuffs can be a very serious problem, occurring in part due to inadequate storage conditions. Contamination may also occur at the preharvest stage and be exacerbated by inadequate storage conditions. Good cropping practices, use of seed varieties bred for resistance to seed infecting fungi and insect pests as well as the use of appropriate approved pesticides represent reasonable preventive measures to control contamination in the field. Even with application of these practices, conditions created by the environment and/or traditional agricultural procedures may defeat any preventative measures.~~

~~1.2 Practices that reduce aflatoxin B1 contamination in the field and after harvest should be an integral part of animal feedingstuff production, particularly for the export market because of the additional handling and transport steps required to get the product to the final destination. The factors most amenable for prevention of fungal infection and aflatoxin B1 production involve proper drying and storage of the feedingstuff prior to transport. The problems created by too much moisture are magnified greatly by deficient post harvest crop handling techniques.~~

~~1.3 Investigations concerning the biological fate of aflatoxin B1 (AFB1) in lactating dairy cattle have demonstrated the transmission of residues into milk, occurring as the metabolite aflatoxin M1 (AFM1). Although AFM1 is considered to be less carcinogenic than AFB1 by at least an order of magnitude, its presence in dairy products should be limited to the lowest level practicable. The amount of daily ingested AFB1 which is transferred into milk is in the range of 0.17 to 3.3%.~~

~~1.4 To ensure the lowest possible level of AFM1 in milk, attention should be given to residues of AFB1 in the lactating dairy animal's daily feed ration.~~

1. Mycotoxins are secondary metabolites produced by fungi of various genera. They can grow on agricultural products before and after harvest, during transportation and in storage. Aflatoxins are a class of mycotoxins that are produced by *Aspergillus* moulds; the most common are aflatoxins B_1, B_2, G_1, and G_2. There are numerous species of *Aspergillus* fungi that produce aflatoxin B_1, although *A. flavus*, and *A. parasiticus* are the two predominant toxigenic species of *Aspergillus* that can proliferate in crops and silages.

2. Aflatoxins are commonly found in agricultural commodities grown in tropical and subtropical regions, including crops used as animal feed. Contamination is most common in African, Asian, and South American regions, but also occurs in the warmer areas of North America and Europe.

3. When feed or feed ingredients contaminated with aflatoxin B_1 are ingested by milk-producing animals, aflatoxin B_1 is metabolized and excreted as aflatoxin M_1 in their milk. The transmission rate of aflatoxin B_1 from feed into milk typically ranges from 1% to 2%, but may be as high as 6% in animals with high milk production.

4. Aflatoxin M_1 has been detected in the milk of ruminant animals such as cows, sheep, goats, buffalo and yaks. Humans can therefore be exposed to aflatoxin M_1 from the consumption of milk and milk products.

5. The 56th meeting of JECFA concluded that aflatoxin M_1 is a genotoxic carcinogen with 10% of the carcinogenic potency of aflatoxin B_1, based on rodent studies.

6. The complete prevention of *Aspergillus* moulds is not practically achievable, even when good agricultural practices (GAP) and good manufacturing practices (GMP) are followed. Measures that reduce the growth of *Aspergillus* fungi pre-harvest and post-harvest should therefore be an integral part of the production of feed for lactating dairy animals.

2. PURPOSE AND SCOPE

7. This code of practice recommends practices based on GAP and GMP that are consistent with Hazard Analysis Critical Control Points (HACCP) principles and which are incorporated into current feed safety practices used in global production, storage, handling, transportation, processing, distribution, and trade. It does not recommend or review new physical, biological, and chemical methods for pre- or post-harvest aflatoxin control, although these are areas of further study.

8. This document focuses on prevention and reduction measures for aflatoxin B_1 in animal feed of agricultural origin that are relevant to milk-producing animals as well as international trade. Feed types include forage crops (e.g. clover, alfalfa, grasses), silage and baleage, oilseeds, soybeans and other pulses. Although cereals are widely used as animal feed, they are not specifically covered in this guidance, unless they are to be ensiled, as cereal grains are addressed in the *Code of practice on mycotoxins in cereals* (CXC 51-2003).

9. The guidance provided in this document can be used by different types of stakeholders including competent authorities, producers, marketers, and processors. Because of differences in regional crops, climate, agronomic practices, analytical methods and standards, as well as product and equipment availability, not all recommended practices will be applicable or practical in all situations or to all stakeholders.

10. In fulfilling the Codex mandate of consumer health protection through the development of food standards, this code of practice does not include information specifically aimed at protecting the health of milk-producing animals or the environment. Notwithstanding, best efforts have been made to ensure that the recommendations in this document will not be detrimental to animal or environmental health.

3. RELATED GUIDANCE

- *Code of practice for the prevention and reduction of mycotoxin contamination in cereals* (CXC 51-2003)
- *Code of practice for the prevention and reduction of aflatoxin contamination in peanuts* (CXC 55-2004)
- *Code of practice for the prevention and reduction of aflatoxin contamination in tree nuts* (CXC 59- 2005)
- *Code of practice on good animal feeding* (CXC 54-2004)[1]
- *General standard for contaminants and toxins in food and feed* (CXS 193-1995)
- *General standard for methods of analysis and sampling* (CXS 234-1999)
- *Guidelines on the application of risk assessment for feed* (CXG 80-2013)
- *Guidance for Governments on Prioritizing Hazards in Feed* (CXG 81-2013)

4. DEFINITIONS

11. **Aerobic stability:** A measure of how long silage stays fresh, especially once the silo is opened. Defined as the time which elapses before the silage shows clear evidence of heating, that is, when the temperature of the silage exceeds the ambient temperature by 2°C.

12. **Baleage:** Partially dried forage that is made into bales that are wrapped or bagged in order to be preserved through anaerobic fermentation (see also 'Haylage' and 'Silage').

13. **Feed; Feed additive; Feed ingredient:** Refer to the *Code of practice on good animal feeding* (CXC 54-2004)

14. **Forage:** Plants, mainly grasses and legumes, but also the non-grain parts of a corn plant, that are consumed by animals, particularly livestock. May be preserved by drying or fermentation (see also 'Baleage', 'Hay', 'Haylage', and 'Silage').

15. **Hay:** Dried grasses and/or legumes, often made into round or square bales.

16. **Haylage:** Silage made from grasses and/or legumes, but not cereals, soybeans, or corn/maize. May refer to material that is either baled or stored in a silo (see also 'Baleage' and 'Silage').

17. **Legumes; Oilseeds; Pulses:** Refer to the *Codex classification of foods and animal feeds*

18. **Milk; Milk product:** Refer to the *General standard for the use of dairy terms* (CXS 206-1999)

19. **Mycotoxin detoxifying agents:** Substances or mixtures of substances incorporated into a feed matrix to reduce animal exposure to mycotoxins.

20. **Silage:** Forage plants of high moisture content such as corn/maize, legumes, and grasses that have been chopped and stored in a silo where they undergo anaerobic bacterial fermentation and are converted to succulent animal feed. (See also 'Baleage' and 'Haylage').

[1] Also refer to: Food and Agriculture Organization and International Feed Industry Federation. 2020. *Good Practices for the Feed Industry: Implementing the Codex Alimentarius Code of Practice on Good Animal Feeding.* FAO Animal Production and Health Manual No. 24. FAO/IFIF, Rome.

21. **Silo:** A structure, vessel, or repository used for making and storing silage. Often an upright cylindrical tower but also a bunker (clamp), bag, pile, pit, or trench that is usually sealed to exclude air.

22. **Ration:** The amount of total feed that is provided to one animal over a twenty-four hour period.

23. **Water activity:** A measure of free moisture in a product. The water vapour pressure of the substance divided by the vapour pressure of pure water at the same temperature. Water activities above 0.70 at 25 °C (77°F) are 'unsafe' as far as growth of *A. flavus* and *A. parasiticus* and possible aflatoxin production are concerned.

5. ~~2.~~ RECOMMENDED PRACTICES BASED ON GOOD AGRICULTURAL PRACTICES (GAP) AND GOOD MANUFACTURING PRACTICES (GMP)

5.1 GENERAL RECOMMENDATIONS

24. Document the harvesting, drying, cleaning, transportation and storage procedures and conditions (e.g. temperature) each season to help identify causes of fungal growth and prevent future occurrences. Validated predictive models can be useful in helping make management decisions.

25. Before use and re-use, ensure all equipment and materials used for planting, harvesting, transporting, drying, cleaning, and storage are:

    a. cleaned of potential sources of contamination (e.g. crop residues, dust, insects, fungal growth, broken glass, animal excrement) and dried. Use approved cleaners and disinfectants that do not cause off-odours or flavours or contaminate the crop.

    b. intact and able to provide protection from water (e.g. precipitation, ground water seepage, condensation) as well as rodents, birds and insects that can contaminate the crop and cause physical damage, making it more susceptible to mould infection. Use registered fumigants or insecticides as needed.

26. Ensure all equipment and materials used for planting, harvesting, transporting, drying, cleaning, and storage are in good working order and calibrated to relevant conditions (e.g. moisture sensors), where applicable. Have spare parts available to minimize time loss for equipment repairs.

27. Monitor for aflatoxin B_1 along the value chain, particularly if spoilage is observed or when the risk of mycotoxin contamination is high as a consequence of unfavourable conditions. Adjust frequency of sampling and testing to take into account conditions conducive to aflatoxin B_1 formation, the regional source of the commodity, and prior experience within the growing season.

28. During all stages of the value chain, avoid mixing, or separate, if already mixed, infected, mouldy, or damaged crop materials from those with lower rates of infection and/or damage. Models could be used to predict aflatoxin B1 production in the field based on environmental conditions.

29. Consult with extension services on how to dispose of or destroy crops, crop residues or feed with high aflatoxin B_1 concentrations that has been deemed unfit for use as feed. If burning contaminated materials, be aware that temperatures greater than approximately 268 °C are required for aflatoxin B_1 to be destroyed.

30. ~~2.1.7 & 2.2.2.~~ Aim to minimize mechanical damage to crops during cultivation, irrigation, pest management practices, harvest and cleaning.

31. Contact product or equipment manufacturers, competent authorities and/or extension services for supplementary information about the practices included in this code of practice. Extension services can advise about aflatoxin mitigation measures relevant to regional conditions and situations.

32. Products used in the production of animal feed that may indirectly prevent or control *Aspergillus* contamination (e.g. insecticides, additives used to support fermentation) or directly reduce aflatoxin levels post-harvest (e.g. additives, mycotoxin detoxifying agents (MDAs)) should be approved/registered and used within the parameters set by competent authorities. Post-harvest aflatoxin reduction measures in particular is an area of further study.

33. Aflatoxin B_1 concentrations in feed may be heterogeneous, therefore it is important that any sampling and testing follow Codex sampling plans or those of competent authorities in order to provide accurate and representative results.

~~2.1 Crop production~~

5.2 PREPARATION FOR PLANTING AND PLANTING

34. Remove or destroy infected crop material left in the field as spores and other fungal structures may survive and serve as inocula for future crops.

35. Plant crops less susceptible to *A. flavus* and *A. parasiticus* such as legumes and oilseeds in rotation with more susceptible crops such as peanuts, maize, sorghum, and cotton. Rotating crops can help reduce the inoculum in the field which may originate from debris remaining after harvest that harbours toxigenic fungal spores.

36. Consider biological control methods like biofungicides and biopesticides that deliberately release competitive, non-aflatoxigenic *A. flavus* and *A. parasiticus* into the agricultural environment in order to suppress the natural occurrence of the aflatoxigenic fungi.

37. ~~2.1.2~~ Test the ~~Utilize~~ soil ~~tests if possible~~ to determine if there is a need to ~~fertilizer needs and~~ apply fertilizer and/or add soil conditioners to assure adequate soil pH and plant nutrition in order to avoid plant stress.~~, especially during seed development.~~

38. ~~2.1.3 When feasible, use seed varieties bred for fungal resistance and field tested for resistance to Aspergillus flavus.~~ Use certified seeds free from toxigenic fungi. Plant varieties (cultivars) recommended for the specific region and which were developed and selected for their traits of providing at least partial resistance to non-toxigenic and toxigenic fungi, insect pests, and *Aspergillus* ~~mycotoxin~~ accumulation.

39. ~~2.1.4 As far as practicable, sow and harvest crops at times which will~~ Time planting to avoid high temperature and drought stress in developing seedlings ~~during the period of seed development/maturation~~. Predictive models, when available, could be used as a tool to help target optimal planting periods.

40. Ensure appropriate density of planting by maintaining the recommended row and intra-plant spacing for the species and varieties grown.

5.3 PRE-HARVEST

5.3.1 Growth Stage

41. ~~2.1.5~~ Minimize insect damage and fungal infection through the proper use of ~~appropriate~~ registered pesticides and other ~~insecticides and fungicides and other~~ appropriate practices within an integrated pest management programme. Predictive weather models could be used to plan the optimal timing and method of application.

~~2.1.6. Use good agronomic practice, including measures which will reduce plant stress. Such measures may include: avoidance of overcrowding of plants by sowing at the recommended row and intra-plant spacings for the species/varieties grown; maintenance of a weed free environment in the growing crop by the use of appropriate approved herbicides and other suitable cultural practices; elimination of fungal vectors in the vicinity of the crop; and crop rotation.~~

42. Control weeds using mechanical methods, registered herbicides or other appropriate eradication practices within an integrated pest management programme. Weeds can act as hosts for toxigenic fungi and increase plant stress due to crowding.

43. Avoid lodging/contact of the aerial plant parts with soil and soil water, particularly at the flowering stage, as these can be sources of fungal spores.

~~2.1.8 Irrigation is a valuable method of reducing plant stress in some growing situations. If irrigation is used ensure that it is applied evenly and individual plants have an adequate supply of water.~~

44. Evenly apply irrigation water to ensure that all plants have an adequate water supply.

45. Determine the moisture content in various locations as moisture may vary considerably within a field. Use moisture sensors or send crop samples to a reputable testing facility. Moisture readings should supplement personal observations and other information about the crop.

5.4 ~~2.2~~ HARVEST

46. Choose an optimal harvest time, avoiding the harvest of crops with high moisture content due to precipitation or morning dew or when drying time and conditions are not optimal for the crop in question.

5.4.1 Non-forage crops

47. ~~2.2.1~~ Allow crops to dry in the field as much as possible before harvest in a way consistent with the local environmental and crop conditions. Harvest at low moisture content, targeting a water activity below 0.7, which generally inhibits fungal growth.

48. Harvest at full maturity, unless allowing the crop to continue to full maturity would subject it to extreme heat, rainfall, or drought conditions. If mechanical drying equipment is available, earlier harvest may help limit aflatoxin production during the final stages of crop maturation.

5.4.2 Forage crops

49. Forage crops are cut in the field and may be wilted or dried to different moisture levels, depending on the intended use. Crops intended to be ensiled need to have enough moisture to ferment properly, whereas hay needs a low enough moisture content to preserve properly. High quality forage, proper fermentation and preservation are important factors for minimizing mould growth.

50. Minimize crop contact with soil and manure that could contain bacteria and fungal spores (e.g. by optimizing cutting height; not applying manure right before harvest).

51. Cut after dew has evaporated and maximize drying time in sunny conditions. Avoid drying during rainfall as much as possible, as rain may splash undesirable soil-borne bacteria onto the crop and leach out soluble sugars which can impact fermentation.

52. Cut the widest swath possible and raise the cutting height to allow air to move under the swath to promote faster drying.

53. For silage, rapidly wilt and dry over a single day to minimize respiration losses of sugars, which can cause dry matter losses. Chop or cut in lengths recommended for the crop and type of silo it will be stored in. Shorter chop lengths pack more densely, which reduces the amount of air, supports fermentation, and allows for more efficient unloading, which reduces oxygen exposure at feed-out. Optimal chopping length for grasses ranges between 4 and 6 cm. Corn silage for dairy cows should contain <1% large particles (>2 cm), 8 to 12% medium particles (1 to 2 cm) and < 50% very short particles (<6 mm).

54. Use a crop conditioner (a piece of farm equipment using a roller(s) or impellor(s)) to crimp or crack the stems to allow moisture to escape and aid drying. Under-conditioning can increase the risk of rain damage and over-conditioning can increase crop losses during cutting, raking, and baling. Use the appropriate conditioner for the crop (e.g. roll for alfalfa; impeller for grasses) and adjust equipment (e.g. roll spacing and spring tension of mower-conditioners) to optimize conditioning and drying and minimize shattering and leaf loss.

55. Alfalfa stems should be crimped or broken every 7.5 to 10 cm. At least 90% of the stems should be cracked or crimped, with less than 5% of legume leaves bruised or blackened. Set the roll clearance at 1.5 to 2.5 mm, slightly smaller than the alfalfa stems, for optimal conditioning.

56. Forage intended for hay should be conditioned to achieve sufficiently low moisture content. Conditioning may not be as important when wide swaths are cut for forages intended for other purposes.

57. Rake into windrows in a uniform fashion, avoiding bunching. After heavy rain, move wetter material from the bottom of the windrow to the outside, break up and aerate any clumped material, or move it onto a drier surface using the appropriate equipment or machinery (e.g. tedder, rake) for the crop and its moisture level (e.g. tedders are better suited for grasses than alfalfa; avoid tedders for alfalfa <50% moisture).

58. Shake off heavy morning dew on cut crops left in the field overnight using appropriate equipment or machinery (e.g. tedder, rake).

59. Rake alfalfa at moisture levels between 30-40% and limit raking at or below 20% moisture to minimize leaf loss (shattering). Rake hay that is almost dry in the morning when the dew is still on the crop to reduce shattering. Ground-driven, wheel rakes are suitable for dry hay production and less suitable for wetter hay materials (e.g. haylage, baleage) as they tend to incorporate soil into wetter crops, which could be a source of fungal or bacterial contamination.

60. Avoid walking or driving on cut material in the field, particularly if the field is wet. Set vehicle tires as wide as possible to help minimize compaction and leaf loss if driving on cut material.

61. Harvest forage that will become silage or baleage at the optimal dry matter concentration and/or moisture level and maturity stage recommended for the crop, geographic area, storage duration, and storage system. A crop's dry matter content at harvest is directly related to its packing density and ability to ferment and maintain anaerobic conditions, which both influence *Aspergillus* growth.

62. The optimal moisture content for making silage is approximately 60-70% and that of baleage is 45-50%, although 40-60% may be acceptable. Moisture should come mostly from the plant, as surface moisture (e.g. dew, rain) does not provide sufficient moisture for fermentation.

63. If testing moisture using hand-held probes, compact the cut forage first as probes cannot accurately measure the moisture content of loose forage (e.g. in a windrow). The accuracy of moisture testers is also influenced by forage composition, stem and dew moisture, and the use of additives.

64. Dry hay should be harvested from the field at a moisture content below 18% for small square bales, and below 14% for large bales. If damp hay must be harvested, hay driers can be effective in drying hay of up to approximately 25% moisture, but this depends on factors such as the hay's composition, bale density, and air humidity.

~~2.2.3 Where applicable dry crops to a minimum moisture content as quickly as possible.~~

~~2.2.4 If crops are harvested at high moisture levels dry immediately after harvest.~~

~~2.4 Transport~~

~~2.4.1 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.~~

~~2.4.2 Protect shipments from moisture by appropriate means such as airtight containers, covering with tarpaulins, etc. Care must be taken in the use of tarpaulins to avoid sweating of the commodity that could lead to local moisture and heat build up which are prime conditions for fungal growth.~~

~~2.4.3 Avoid insect and rodent infestation during transport by using insect resistant containers or insect and rodent repellent chemical treatments.~~

~~2.5.2 Use an appropriate sampling and testing program to monitor outbound and inbound shipments for the presence of AFB1. Because AFB1 concentration in shipments may be extremely heterogeneous refer to FAO recommendations for sampling plans.~~

5.5 PREPARATION FOR STORAGE

5.5.1 Non-forage Crops

65. Minimize transit time from field to drying facility unless the crop is already at acceptable storage moisture levels before harvest. Open transport containers to increase aeration and minimize the condensation effects.

66. ~~2.2.5~~ Avoid piling, ~~or~~ heaping or bin storage of high-moisture, ~~wet~~ freshly harvested commodities for more than a few hours prior to drying or threshing to lessen the risk of fungal growth.

67. Before drying, remove foreign plant material, especially that which may carry mould or fungal spores. Dry to a moisture content corresponding to a water activity less than 0.70 (preferably 0.65). Maximum moisture levels of 10-15% are generally considered low enough to prevent further growth of pre-harvest toxigenic fungi and germination of fungal spores.

68. Dry crops immediately after harvest and prior to storage. If immediate drying is not possible, aerate by forced air circulation and minimize the time until drying. Mechanical drying is preferred. Flat bed and re-circulating batch driers are adequate for small scale operations while using a continuous flow-dryer is preferred for large scale drying prior to long storage periods. Avoid accumulating too much crop in the pre-drier storage or "wet tank", especially when climactic conditions are warm.

69. Store only enough crop that can be easily dried in a suitable time period. When intermediate or buffer storage is necessary because of low drying capacity, aim for crop moisture content less than approximately 15-20% and crop temperature less than 20°C, respectively, and buffer storage time less than 10 days, although these parameters will vary with the crop and environmental conditions.

70. ~~2.2.6 Ensure adequate protection from rain during sun drying.~~ If mechanical means of drying are not available, ensure sun and open air drying surfaces are clean. Protect crops from rain, dew, soil, pests, bird droppings and other sources of contamination during this process. For more even and faster drying, mix or stir frequently and dry in thin layers.

71. Crops should not be excessively dried or subjected to excessively high drying temperatures in order to preserve nutritional quality and suitability for milling or other processing. Use proper drying techniques to avoid generating contaminants such as polycyclic aromatic hydrocarbons (PAH) and dioxins[2].

72. After drying, clean and sort to remove damaged and immature seeds and foreign matter. Lots containing higher levels of aflatoxin B_1 should undergo extensive cleaning and processing. Seeds containing symptomless infections cannot be removed by standard cleaning methods.

73. Seed cleaning procedures such as gravity tables, optical sorting (e.g. using UV light or fluorescence), air separators, sieves, and floatation may remove infected or broken seeds that are susceptible to infection. Novel sorting techniques are a further area of study as are chemical, biological, and physical methods of post-harvest aflatoxin B_1 control (e.g. microbial degradation, high temperature (>268 °C), irradiation, electromagnetic radiation, ozone, cold plasma, nanoparticles, ammonia).

~~2.3 Storage~~

~~2.3.1 Practice good sanitation for storage structures, wagons, elevators and other containers~~

~~to ensure that stored crops will not be contaminated. Proper storage conditions include~~

~~dry, well ventilated structures that provide protection from rain or seepage of ground~~

~~water~~

~~2.3.4 Prevent insect infestation by the use of appropriate approved insecticides.~~

~~2.3.5 Ensure that the storage facilities are free of insects and mould by good housekeeping and/or the use of appropriate approved fumigants.~~

~~2.3.6 Prevent access by rodents and birds.~~

~~2.3.8 Use of a suitable authorized preservative e.g. an such as proprionic acid, may be beneficial in that such acids are effective in killing moulds and fungi and preventing the production of mycotoxins. If organic acids are used, it is important that the amounts added are sufficient to prevent fungal growth and is consistent with the products end use~~.

5.6 STORAGE

74. Cut vegetation around storage areas to reduce rodent cover.

75. Adjust storage conditions and duration based on weather conditions. Cool temperatures work in favour of preservation and help keep fungal activity low. Longer storage times are generally associated with increased risk of mould growth.

76. Regularly monitor stored crops to ensure relevant conditions (e.g. temperature, moisture, oxygen, pH, pests, structure, material integrity) are stable and appropriate for the type of storage system being used, as significant changes can promote mould growth. Monitor the aflatoxin B_1 level in the crop using appropriate sampling and analytical procedures, particularly if spoilage is observed.

77. Use registered insecticides and fungicides or appropriate alternative methods within an integrated pest management programme. Ensure any residues remaining in the crop meet the maximum levels established by competent authorities. Organic acids (e.g. propionic, formic, citric, acetic, lactic) and their salts (e.g. calcium propionate) are common fungicides that can be applied post-harvest to crops stored dry or fermented. The salts are usually more effective for long-term storage.

5.6.1 Non-forage crops

78. Store at the moisture content recommended to limit *Aspergillus* growth, which will vary based on crop quality, variety and seed size, length and conditions of storge, and environmental conditions.

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[2] As outlined in the *Code of practice for the reduction of contamination of food with polycyclic aromatic hydrocarbons (pah) from smoking and direct drying processes* (CXC 68-2009) and the *Code of practice for the prevention and reduction of dioxin and dioxin-like PCB contamination in food and feeds* (CXC 62-2006)

79. For maize, the moisture content should be no more than 15.5% and lower moistures would be required for certain climates and durations of transportation and storage.[3] The recommended moisture contents for certain pulses are summarized in the table below.[4] As these moisture contents are specific to maize and pulses intended for human consumption, higher moisture contents may be tolerable for maize intended for animal feed.

Recommended moisture of certain pulses at two storage durations and climactic conditions

Pulse (with seed coat)	**Moisture Content** (%)*	
	Tropical climates, long-term storage (>1 crop year)	Moderate climates, short-term storage
Beans	15	19
Lentils	15	16
Peas	15	18
Chick peas	14	16
Cow peas	15	18
Field beans	15	19
*In the case of pulses sold without their seed coat, the maximum moisture content shall be 2% (absolute) lower in each case		

~~2.3.3 Ensure that crops to be stored are free of mould and insects and are dried to safe moisture levels (ideally crops should be dried to a moisture content in equilibrium with a relative humidity of 70 %).~~

~~2.3.7 Store at as low a temperature as possible. Where possible aerate commodities stored in bulk through continuous circulation of air through the storage vessel to maintain proper temperature and moisture.~~

80. Aerate by circulation of air through the storage vessel to maintain proper and uniform temperature and moisture levels. Aerate using air of lower ambient temperature than that of the stored crop so condensation and water activity do not increase.

81. Transfer crops from one storage container to another to promote aeration and disrupt potential hot spots during storage.

82. ~~2.3.2 For bagged commodities, ensure that bags are clean and dry and stack~~ Stack bagged crops on pallets or incorporate a water impermeable layer between the sacks and the floor. Bags should facilitate aeration and be made of non-toxic food grade materials of a thickness appropriate for the length of the storage period.

5.6.2 Silage

83. *Aspergillus* species can survive under the anaerobic and acidic conditions created in silage, therefore proper storage conditions are important for minimizing aflatoxin production. Once pH reaches 3.8-4.5, the silage should keep for an extended period of time provided that air is excluded from the ensiled material.

84. Target a moisture content of 60-70% to allow adequate compaction and provide good fermentation; the appropriate dry matter and/or moisture content will vary depending on the crop. Ensure the material is not excessively wet as wet silage can leach out sugars needed for fast and efficient fermentation.

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3 Source: *Standard for maize (Corn)* (CXS 153-1985). This standard states that it applies to maize (corn) for human consumption, i.e., ready for its intended use as human food, presented in packaged form or sold loose from the package directly to the consumer.

4 Source: *Standard for certain pulses* (CXS 171-1989). This standard states that it does not apply to pulses intended for use in the feeding of animals.

85. Choose a silo capacity based on the feeding needs of the farm (herd size, typical rations) and the amount of material to be ensiled. This helps ensure complete filling of the silo, which aids in self-compaction, and minimizes air exposure at feed-out. Locate silos as close as possible to where the silage will be fed to animals to minimize air exposure at feed-out.

86. Fill silos rapidly, immediately after harvest. Compact forage quickly to exclude air and achieve the recommended bulk density. Compact the silage in layers, if the silo type allows, which is particularly important in shorter silos with lower self-compaction potential. If pits are being used, those that are long, deep and narrow are easiest to fill and progressively compact. Ensure adequate packing, particularly along the top and side walls of tower silos (use of a distributor can be helpful). Avoid contaminating silage with soil, manure or other debris when compacting.

87. Silos bags are best used as temporary storage. If used for longer-term storage, place on a well-drained, weed-free base.

88. For bunker silos, target a silage density of 224-240 kg dry matter/m^3 (14-15 lb dry matter/ft^3). Fill from back to front in a wedge shape with a 1:4 slope. Pack in layers no more than 15 cm thick to increase aerobic stability at feed-out.

89. Seal the silo immediately and completely after filling, and between fillings if that time period is lengthy, to preserve anaerobic conditions. Sealing is especially important in shorter and wider silos (e.g. bunkers) where a greater portion of crop material has the potential to be exposed to air. Seal with oxygen barrier plastic film designed for covering silage or 6- or 8-mil[5] plastic film. Avoid transferring the silage from one silo to another, which can expose the silage to oxygen and impair its aerobic stability.

90. Use plastic on the side walls of concrete bunkers and fold over the silage when the bunker is full to help prevent precipitation on the inside walls. Cover the concrete edges of the bunker (e.g. with drainage conduit) to protect the plastic that is hanging over the side walls from ripping during filling.

91. Ensure uniform and adequate distribution of weight on top of any plastic used to cover silage, especially on the shoulders of the silo. Weigh down plastic with suitable material (e.g. tires, sand, or gravel-filled bags, soil) and ensure sufficient coverage to minimize air contact with the silage.

5.6.3 Baleage

92. Baleage is drier than silage therefore does not ferment completely and produce as acidic conditions. Preventing air from entering the bales at the time of baling and throughout storage is the main method of preservation. Using high quality forage helps ensure proper fermentation (e.g. mature forage is more difficult to make into tight bales as it does not pack as densely).

93. Exclude air quickly and completely when bales are being made, targeting a density of approximately 192 kg/m^3. If bales are wrapped with twine, use a type of twine that does not degrade the plastic bale wrapping.

94. Fully enclose bales as quickly and tightly as possible in wraps, bags, tubes, or covered stacks. Storage should be completed no more than 6 to 12 hours after baling. Use plastic that is free from holes, stretchy, puncture resistant, inhibits ultraviolet light, and has a uniform thickness. Sticky material also help create a tight seal.

95. If wrapping, follow the manufacturer's instructions regarding the recommended number of layers. Typically, at least 4 layers of wrap are recommended for short storage durations and up to 6 layers for bales stored up to a year.

96. Bags should be the appropriate thickness for the intended storage duration. Lighter (e.g. 4-mil) plastic typically has a 1-year life expectancy while thicker bags (e.g. ≥5-mil) may be used for 2 seasons if holes are thoroughly patched before reusing. Tubes (e.g. flex tubes) are advantageous due to their tight fit. Ensure tubes and bags are continuously sealed and tightly tied off at their open ends.

97. Cover stacks of unwrapped bales with a double layer of polyethylene plastic (e.g. 6-mil) or silage film intended for this purpose. The outer cover provides the seal and the inner layer protects the outer layer from punctures. Seal the outer cover along its edges (e.g. with sand) and tie or weigh it down. The amount of air initially trapped under the plastic is not critical, but if the initial seal is broken, oxygen will enter and cause spoilage. Place loose haylage in any gaps between the bales and between the bales and plastic cover to restrict air movement if the seal is broken.

5 1 mil = 1/1000 of an inch or 0.0254 mm

98. Use equipment or machinery that does not puncture the plastic seals. If the plastic is damaged, immediately use the baleage as feed or patch the hole with silage tape. Tiny holes allow enough air exchange to cause spoilage at the bale face that can penetrate into the bale.

99. Use a storage system that minimizes air re-entry at feed-out. Individually wrapped bales and shorter lines of grouped bales may be most suitable, however, systems should be chosen based on the characteristics of each farm (e.g. feed-out times, herd size, climate). Once a storage unit is opened, it should be rapidly and entirely fed-out.

5.6.4 Additives in silage and baleage

100. Microbial inoculants (e.g. lactic acid bacteria, yeast) are commonly used in silage and may also be used in baleage to speed fermentation and maintain acidity and aerobic stability, which reduce the potential for mould growth. They can also adsorb aflatoxin B_1 and reduce mycotoxin production by *Aspergillus* moulds as a result of the organic acids and other compounds they produce.

101. Microbial inoculants may be particularly useful when forage is drier than recommended or the wilting conditions are cool and dry.

102. Carbohydrate supplementation (e.g. molasses, whey) alone or combined with microbial inoculation promotes fermentation. Crops with few water-soluble carbohydrates (e.g. alfalfa) may need supplemental carbohydrates.

103. Applying inoculants at the chopping stage works well, particularly with drier forage. Liquid inoculants can often be applied in a more uniform manner than granular products.

104. Store microbial inoculants in a cool, dry place to maintain bacteria viability. Ensure they are sealed to prevent water and other contamination.

105. Feed additives that directly and indirectly control aflatoxin levels, and which could be used alone or with microbial inoculants, is an area of further study (e.g. enzymes, copper sulphate, essential oils, nanoparticles).

5.6.5 Hay

106. Store in an enclosed area to prevent spoilage caused by moisture from precipitation and moisture wicking up from the ground. Maintain 60 cm (24 inches) between hay and the roof of the structure and 50 cm (20 inches) between the hay and the structure's walls to promote air flow.

107. If an enclosed storage area is not available, wrap bales or use a bale sleeve. Bales wrapped in nets tend to be wound more tightly than those wrapped in twine and shed rain more effectively, resulting in less spoilage. Cover with tarps, especially square bales that have less ability to shed water. Secure the tarps to the bales or weigh them down (e.g. with tires, sandbags).

108. Stack bales with some space between them to prevent rainwater and moisture from becoming trapped between them and to allow the bales to sweat.

109. Place bales on a dry, well-draining base such as gravel or pallets to reduce moisture on the bottom of the hay. Do not store round bales on their flat end as this results in a greater surface area touching the ground and increases their potential to wick up moisture.

110. Organic acids sprayed on hay (e.g. as it enters a baling machine) can help prevent mould growth in hay that could not be dried to the desired moisture level. Use the highest of multiple moisture readings to determine the application rate to ensure sufficient additive is used.

111. Do not store hay treated with acid preservatives in direct contact with untreated hay as moisture will migrate to the untreated hay.

5.7 ANIMAL FEEDING

~~2.5 Feed production and disposition of AFB1 contaminated animal feeds~~

~~2.5.1 Ensure that milling equipment is kept clean, free of dust and feed accumulation.~~

~~2.5.3.2 If feed restriction is not practical, divert the use of highly contaminated feedingstuffs to non-lactating animals only.~~

112. Be aware of feed ingredients that may contain elevated aflatoxin levels, such as certain grain or seed fractions (e.g. hull, bran), agricultural or food industry by-products, and products intentionally diverted from the human to the animal food stream.

113. Lactating animals should be prioritized for feeding rations with the lowest possible aflatoxin contamination.

114. ~~2.5.3 If aflatoxin B1 is detected, consider one or more of the following options. In all cases ensure that the aflatoxin B1 level of the~~ Ensure the aflatoxin B_1 level in finished feed is appropriate for its intended use (e.g. lactation status, maturity, animal species) and ~~is consistent with national codes and guidelines or qualified veterinary advice.~~ meets the recommended or regulated limits established by competent authorities, or, if none are available, that levels are as low as reasonably achievable.

5.7.1 Silage and Baleage

115. The aerobic conditions created during feed-out of silage and baleage give toxigenic molds that are normally less tolerant of acidic or anaerobic conditions an opportunity to grow. Structures with large exposed surfaces (e.g. bunker, pile or pit silos) have the greatest challenges with aerobic stability during feed-out. Adjust feed-out rates based on regional climactic and weather conditions.

116. For silage, minimize air exposure during feed-out by making a clean, complete cut at the silage face and maintaining a straight and firm face. Rapidly progress through the silage face. In temperate climates, use a minimum feed-out rate of 10-16 cm/day during the winter and 25-35 cm/day during the summer. In tropical climates, a feed-out rate of 30 cm/day is recommended for maize silage. Feed silage to livestock immediately after removal from the silo.

117. Bales should be entirely fed-out after opening the wrap, tube or other storage structure. In temperate climates, feed-out should be no more than 1 week in summer, 2 weeks in spring and fall, and 4 weeks in winter.

5.7.2 Decontamination measures

~~1.5 To date there has been no widespread government acceptance of any decontamination treatment intended to reduce aflatoxin B1 levels in contaminated animal feedingstuffs. Ammoniation appears to have the most practical application for the decontamination of agricultural commodities, and has received limited regional (state, country) authorization for its use with animal feed under specified conditions (i.e. commodity type, quantity, animal). Also, research suggests that the addition of the anticaking/binding agent "hydrated sodium calcium aluminosilicate" to aflatoxin contaminated feeds may reduce AFM1 residues in milk, depending on the initial concentration of AFB1 in the feed~~.

118. Feed additives that prevent mycotoxin uptake in animals are commonly referred to as mycotoxin detoxifying agents (MDAs). These agents either physically adsorb/bind mycotoxins (e.g. clay minerals, yeast, activated charcoal), degrade or biotransform them (e.g. enzymes produced by bacteria or yeast), or exhibit both mechanisms of action (e.g. lactic acid bacteria). More specifically, these compounds may reduce gastrointestinal absorption of the mycotoxin in the animal, decrease bioavailability, promote excretion, or modify its structure.

119. Certain MDAs may be approved by competent authorities in certain regions, their development continues to be an area of further study.

5.7.3 Dilution / Blending

~~2.5.3.1 Consider the restriction of AFB1contaminated feed to a percentage of the daily ration such that the daily amount of AFB1 ingested would not result in significant residues of AFM1 in milk.~~

~~2.5.3.2 If feed restriction is not practical, divert the use of highly contaminated feedingstuffs to non-lactating animals only.~~

120. If approved by competent authorities, contaminated feed could be mixed with uncontaminated feed to reduce aflatoxin levels in the ration and enable it to meet any applicable aflatoxin B1 limits. Not all competent authorities approve of this practice. Dilution/blending does not guard against 'hot spots' in feed materials.

121. The dilution of contaminated silage can reduce the feed-out rate of the ensiled material, which can promote mould growth.

APPENDIX III

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APPENDIX IV

Nationally Approved Aflatoxin Control or Detoxification Agents and Technologies for Animal Feed

(non-exhaustive – populated based on voluntarily provided information from member countries or organizations)

(For information)

Post-Harvest Mould Inhibitors/Preservatives

Country	Active Ingredient	General Registration & Use Information	Directions for Use
Canada	Methylparaben (or Methyl p-hydroxybenzoate)	Mould inhibitor products (mixed feeds) containing listed active ingredients require registration in Canada.	Methylparaben is for use as a mould inhibitor in feeds in an amount not to exceed 0.1 percent of the total diet.
	Propylparaben (or Propyl p-hydroxybenzoate)		Propylparaben is for use as a mould inhibitor in feeds in an amount not to exceed 0.1 percent of the total diet.
	Sodium benzoate		Sodium benzoate is for use as a mould inhibitor in feeds in an amount not to exceed 0.1 percent of the total diet.
	Formaldehyde 37% solution (or Formalin)		Formaldehyde 37% solution shall not be used in an amount to exceed 0.25% of the total diet.
	Propionic acid		Propionic acid use varies according to mould inhibitor product.
	Various products approved, most using propionic acid as the active ingredient.		
United States	None approved to date.		

Aflatoxin Detoxification Agents*

Country	Product Name	Registrant Name	Active Ingredient	Year of First Registration	Directions for Use
Canada	NovasilPlus Mycotoxin Binder	BASF	Calcium bentonite	2022	- ruminant feeds not exceeding 20 ppb aflatoxins, as laid out in the *Canadian Feeds Regulations,* Standards and General Requirements, 19(1)(i) - 0.5-2% of total diet (dry matter basis)
United States	None approved to date.				

*Substances added to animal feed to reduce mycotoxin contamination through adsorbing/binding or degrading/ biotransforming the toxin

Novel or Emerging Physical, Biological or Chemical Technologies*

Country	Product Name	Registrant Name	Active Ingredient	Year of First Registration	Directions for Use
Canada	Non approved to date				
United States	None approved to date				

*Examples include field-level strategies (e.g. nanotechnology, biotechnology including biopesticides, biostimulants) and decontamination using ozone, cold plasma technology or electromagnetic radiation

APPENDIX V

National Regulations for Aflatoxin B_1 in Animal Feed

(Non-exhaustive – populated based on voluntary information from member countries or organizations)

(For information)

eCountry	Feed and Animal	Aflatoxin B_1 (µg/g or ppb)	Reference
Canada	Feedingstuff ingredients	20	RG-8 Regulatory Guidance: Contaminants in Feed (formerly RG-1, Chapter 7) - inspection.canada.ca
United States	Dairy animals Breeding beef cattle Finishing beef cattle	20 100 300	Guidance for Industry: Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Feed August 2000
European Commission	Complete feedingstuffs for cattle, sheep and goats with the exception of: -complete feedingstuffs for dairy animals -complete feedingstuffs for calves & lambs Complementary feedingstuffs for cattle, sheep and goats (except dairy animals, calves & lambs) Other complementary feedingstuffs	20 5 10 20 5	Directive, 2003/100/EC, amending Annex I of Directive 2002/32/EC

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