FIELD GUIDELINES FOR THE ASSESSMENT AND MANAGEMENT OF AFLATOXINS IN DAIRY PRODUCTS ACROSS THE SUPPLY CHAIN

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The aim of this document is a communication on current practices for controlling mycotoxins in the milk supply chain. While different levels of controls for aflatoxins are used around the world, aflatoxins are generally considered a critical contaminant and a good indicator to measure the appropriateness of feed controls in the food supply chain.

Mycotoxins are natural toxins produced as secondary products of mold growth in grains, silage and feeds (1, 2). Mold growth and mycotoxin production is promoted by increased humidity and temperature. Crops stressed by drought and insect lesions are more susceptible to mold contamination and growth during harvest, drying and sto rage. During harvests, rain, high humidity and wet weather can prevent rapid and proper grain/silage drying, thereby supporting mold growth. The risks associated with mycotoxins in animal feedstuffs can be reduced to acceptable levels when crop health and extrinsic factors such as humidity and temperature during growth, harvesting and storage are appropriately considered (3).

A variety of negative animal and human health implications can occur when dairy animals consume mycotoxin-contaminated feedstuffs (4, 5, 6). Aflatoxins, predominately aflatoxin B1 (AFB1), produced in susceptible feed bases and feed additives, such as corn, wheat, peanuts, cotton seed, sunflower, etc. are of great concern because they can cause cancer in addition to being highly toxic. Aflatoxins in feedstuffs are the only mycotoxins that are currently considered to be of concern with respect to carry over into milk and the safety of dairy products. It is currently believed that other mycotoxins in cattle feed are either detoxified by microorganisms in the rumen or are not significantly carried over into the milk (7). However, although not transferred to milk, other mycotoxins may have detrimental effects on animal health and milk yield (8).

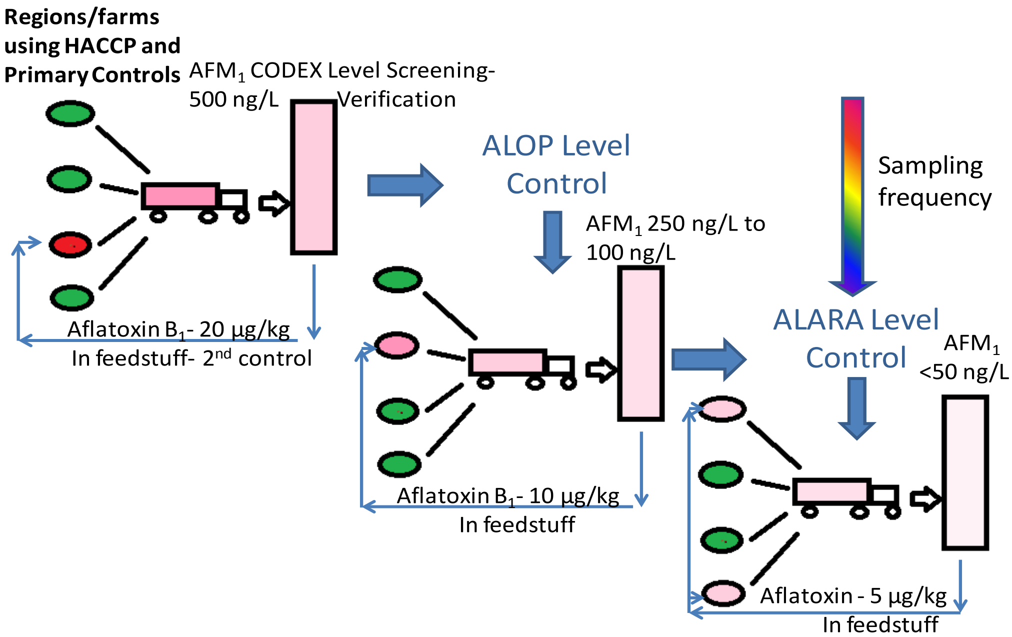
When contaminated feedstuffs are ingested by dairy animals, AFB1 will enter into their blood stream where the liver will convert the AFB1 toxin to aflatoxin M1 (AFM1) which can be excreted into milk. On average, the carry-over in milk amounts to 2,5% of AFB1 ingested with feed, ranging 1-6%. (8, 9). AFM1 has similar toxicity to AFB1, but its carcinogenicity is approximately 10 fold lower (10). Aflatoxin contamination occurring in the feed or food material is practically impossible to eliminate, so management systems target prevention, raw product verification, and early warning with remedial corrective steps. AFM1 will appear in milk approximately 12-24 hours after ingestion and fortunately will eliminate from cattle rapidly in 3-5 days after removal or treatment of affected feed source (8, 9).

The CODEX ALIMENTARIUS COMMISSION has established a maximum limit, an *adequate level* of *protection* (ALOP), for AFM[1] in milk of 500 nanograms per liter (ng/L), which is commonly referred as 500 parts per trillion (ppt) (11). Regulated levels (MRLs and ADIs) may differ across jurisdictions/countries and by product type and control objectives may vary based on these levels and product types. In the case of aflatoxins many in the dairy industry worldwide choose to try to operate under the lowest possible levels of aflatoxin in the dairy chain, i.e. at lower levels than the food safety limit established by Codex. Such lowest possible levels are known *As Low As Reasonably Achievable* (ALARA). Under ALARA principles, IDF suggests the maximum limit for AFM1 in milk should be set at 50 ng/L (ppt) (12). The European maximum limit (ML) for AFM1 is based on this 50 ng/L ALARA level.

As for any food product, effective safety management systems for dairy products should integrate good practices throughout production and adoption of consistent sanitary protocols in a preventive, proactive, Hazard Analysis Critical Control Point (HACCP) approach. These should be implemented across the supply chain from oversea suppliers, to local sources, and all the way to the cow's mouth. One of the biggest areas of concern is on farm storage and basic feed hygiene/ phytosantitary practices (8). Control of AFM1 in milk is most effective when source directed. Thus, control is typically focused on assessing and auditing of feed mills and feed producer's storage and quality systems and control for preventing mycotoxins in purchased and stored feed. This is critically important for aflatoxins due to their persistence once formed, as previously mentioned. Such practices and protocols should include moisture, temperature and time controls to minimize risks associated with AFB1 production in grains and feed ingredients, from harvest to feeding. This is particularly important when feed crops and ingredients originate from areas with a subtropical or warm temperate climates that can promote mold contamination and growth. Some of the most critical feed raw materials can better be avoided or minimized (e.g. coconut cakes, cotton seed cakes and rice flour/husks). In addition, it is important to implement a variety of analytical controls at the feedstuff level with periodic rapid, on-farm screening of the grains and feed ingredients for AFB1, and source removal whenever required (3, 8, 9, 12,13). Moreover, when grain sources or weather conditions indicate an elevated risk to feedstuffs and regional breakdown of the controls, raw milk may be screened for AFM1 prior to acceptance into dairy processing to further verify its safety. This integrated safety management system is depicted in figure 1 and further discussed in the proceeding paragraphs.

Primary control of mycotoxins, aflatoxin in this example,

Figure 1: Integrated Feedstuff and Milk Management of Aflatoxins



Integrated Feedstuff Aflatoxin Controls in Milk Production. Red (strongly contaminated), green (not contaminated) and pink (slightly contaminated or diluted with un-contaminated). Farm regions producing milk (ovals) fill trucks carrying milk to dairy silos (rectangles).

is with good agricultural practices and HACCP in the production and storage of feeds. In the case of aflatoxins, milk screening may be done as an assessment and verification of these primary feed/ingredient controls. When aflatoxin M1 (AFM1) is detected in milk at any control level, producer samples may be used to identify source of contamination. Feedstuffs may then be screened for aflatoxin B1 to quickly remediate and eliminate the contamination. Milk screening frequency can decrease as risk decreases and control levels, Adequate Level of Protection (ALOP) and As Low as Reasonably Achievable (ALARA), are sustained.

The primary controls at the feedstuff level are to adequately prepare dried feedstuffs and store them under vented overhead protection. Feed dryness (in % water by weight) is most important in mold control, and can be evaluated by a number of convenient methods such as weight-loss-on-drying, dielectric constant, near infrared, capacitance and Karl Fisher chemistry. However, the best indication of effective moisture control is given by water activity (aw) of the grain or feedstuff, which relates to the water that is effectively available in the material to support mold growth. For all feed ingredients, and especially when new feed ingredients are introduced into feedstuff, the control systems such as harvest, storage conditions, and aw of those ingredients should be strictly and consistently documented generally below 0.65 (14). Additionally, certain feedstuffs, such as copra, cotton seed, peanut and tree-nut hulls, have historically been a source of mycotoxin contamination into feedstuff and thus present an elevated risk of contamination. In cases where control systems for those ingredients are unknown, or whenever higher risk feed ingredients are being blended into feedstuffs, it is prudent to use a screening method to test the sample or ingredient prior to its use.

When primary controls for a specific process are effective along a time-series of evidence, the sampling frequency of the feedstuff or ingredients for verification of mycotoxin control might be reduced according to an attenuated sampling plan (15, 16); whereas, when primary controls are challenged with crop damage, weather or climatic events, or when positive samples are detected, the frequency of sampling verification should be increased to normal levels or even to increased levels. If feedstuff testing shows contamination, a secondary safety control consists of screening feedstuff and blending, treating or removing the grain source or ingredient from the food supply, along with laboratory confirmatory testing whenever possible. Some regulations, in EU for example, do not allow blending of feeds to reduce AFB1 levels (17). In such cases allowable dietary binding agents to bind or degrade mycotoxins in the rumen/intestine of the animal may be used to allow consumption of contaminated feeds while reducing risk of AFM1 in milk (8).

Fast, field-applicable screening tests are commercially available, (8). For instance, the U.S. Department of Agriculture Grain Inspection, Packers and Stockyards Administration, publishes methods that meet their liquid chromatography based performance specifications (18). The screening test levels which should trigger ingredient or feedstuff culling may vary depending on regions and different regulatory objectives, such as ALOP and ALARA in the milk supply. For example, US and Brazil control corn and feed ingredients at 10 to 20 micrograms per kilogram (µg/kg), commonly referred to a part per billion (ppb), aflatoxin B1 and achieve ALOP control, while the EU controls feed commodities at 5 µg/kg total aflatoxin and achieve ALARA control (19).

Some relevant feed sampling protocols are specified by USDA-GIPSA, ISO and EC (18, 19, 20). It should be emphasized that feedstuff or ingredient screening, among other secondary controls, should not be solely relied upon to protect the milk supply. Rather, primary food safety practices such as good agricultural practices, good manufacturing practices and the adoption of the HACCP (hazard analysis, critical control point) should be the first priority. This is because mold growth and toxin production in feed ingredients is heterogeneous, concentrating in hot spots, and episodic and can challenge the best sampling plans available due to limited sampling locations and sample sizes.

Among other secondary controls for aflatoxin, cow herd ingestion of feedstuff is much larger than feedstuff sampling sizes; thus the cow could be viewed as a larger feedstuff sampler, and their produced milk an extractor/detector of contaminated feedstuff. AFM1 contamination in milk is homogenous unlike the heterogeneous AFB1 contamination in feeds. Therefore, dairies might elect to screen milk as a verification of a safe feed supply and through this contribute in quickly detecting sources of mycotoxin contamination. This voluntary milk sampling and screening is also useful to estimate the risk of aflatoxin contamination in feedstuffs on farms and geographical regions, especially when a solid body of test results is generated over time. Milk screening tests can be selected based on publications of field applicability, detection levels and precision parameters (8, 18, 21, 22, 23). In addition to using raw milk for primary control verification purposes, increased testing of raw milk could be the final verification of compliance with the established limit and safety of subsequent manufactured dairy product when secondary feedstuff screening steps are in place.

When primary controls of grain and feedstuff ingredients need supplementation with screening for AFB1, a secondary verification of control may be accomplished with milk screening for AFM1 in an integrated approach. Different degrees of toxin control can be implemented. Controlling feedstuff at 20 µg/kg AFB1 will produce milk meeting the adequate level of protection (ALOP) or CODEX level of 500 ng/L. If milk screening methods are used at their limit of detection rather than the adequate toxin level, feedstuff, farms and regions contributing to the baseline aflatoxin levels can be identified. Removing these feedstuffs at less than 20 µg/kg, for example 10 µg/kg, can reduce the baseline levels of toxin in the milk supply. When feedstuffs are controlled to 2 to 5 µg/kg AFB1, milk levels of AFM1 are typically lower than 50 ng/L or as low as reasonably achievable (ALARA).

The mycotoxin control systems in place for the safety of milk, milk products, and dairy animal feedstuffs allows for screening at levels lower than action levels, for example at the feed or milk screening methods' limit of detection. Such high sensitivity screening can provide verification of primary controls effectiveness or an early warning of feedstuff or milk producing regions contributing to elevated yet not actionable toxin levels. Such early warning can then allow feed and ingredient screens, among other primary feed controls correction/remediation, that provide the most sustainable safety control of mycotoxins by minimizing public health risks and the economic loss of milk products, milk or animal feedstuffs.

Resources

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