Mycotoxins in dairy production in Asia

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Over the past two decades, the dairy industry in the Asia-pacific region has gained a stronghold in the global scenario.

With India ranking first in milk production, closely followed by China, Russia, Pakistan and New Zealand, this region has a tremendous potential for growth in dairy production as well as trade.

However, mycotoxin contamination of feedstuffs has been proving a major deterrent in realising this potential. Mycotoxins, the toxic metabolites produced by moulds, are unavoidable contaminants of feedstuffs.

The occurrence of different mycotoxins and levels of contamination differ tremendously among different feedstuffs and geographical locations. Animals are fed a blend of different feedstuffs each of which may be contaminated by one or more fungi capable of producing an array of different mycotoxins. Therefore, many mycotoxin interaction situations are possible in a single feed.

Asia-Pacific scenario

Asia-Pacific accounts for nearly one third of the world's milk production. India ranks first in milk production with 91 million tons, closely followed by the USA at 83 million tons in 2006 (FAO).

China, Russia and Pakistan occupy the next three positions indicating the vast growth potential for the dairy sector in the Asia-Pacific.

These countries are followed by:

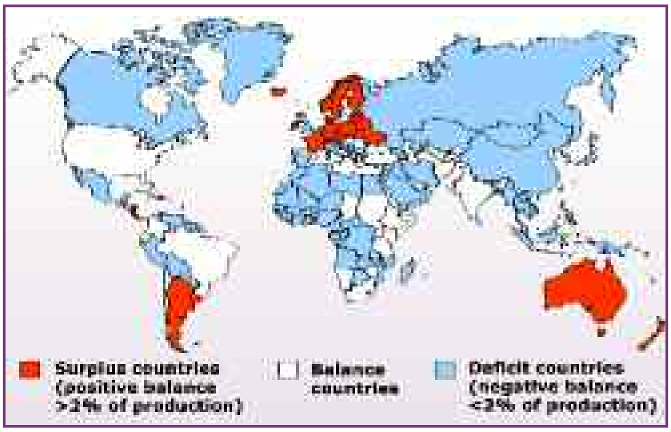
- Germany 28 million tons.
- Brazil 25 million tons.
- France 24 million tons.
- New Zealand 15 million tons.
- Ukraine 14 million tons.

Both the actual data and the projections by FAO suggest that the Asian countries, especially the developing countries, take a significant position in the world dairy scenario.

The scope for growth in the dairy sector in Asia-Pacific stems from:

- Only Oceania countries (Australia and New Zealand) are the surplus countries.
- India and Pakistan are balance countries.
- All the other countries are deficit countries (Fig. 1).

Fig. 1. Global dairy production status.



Mycotoxins of importance

Several mycotoxins are known to affect dairy animals in different ways. Some major mycotoxins that are highly prevalent and are singly capable of causing serious adverse effects on the dairy industry are:

- Zearalenone.
- Vomitoxin and fusaric acid.
- T-2 toxin and diacetoxyscirpenol.
- Aflatoxins and cyclopiazonic acid.
- Fumonisins and moniliformin.

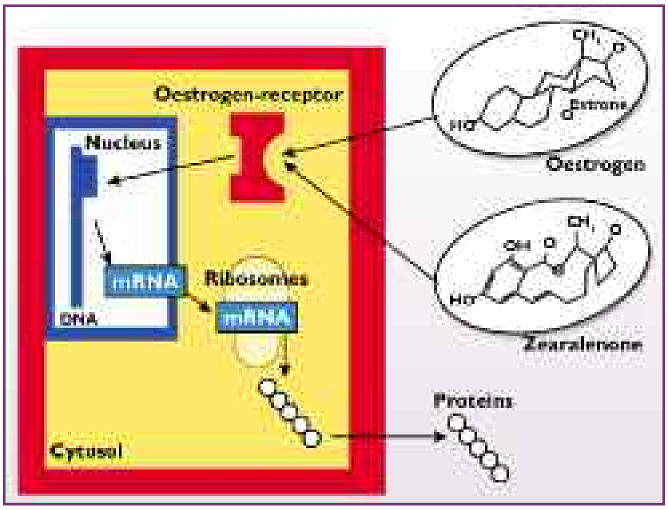


Fig. 2. Oestrogen mimicking the action of zearalenone (adapted from Riley and Pestka, 2005).

These mycotoxins are the ones commonly found in dairy feedstuffs, especially grains and grain by-products. Dairy animals are also exposed to an additional source of mycotoxins through roughage fodder. The mycotoxins commonly affecting dairy animals through forages, pasture and silage are:

- Ergot alkaloids.
- Patulin.
- Vomitoxin.
- Zearalenone.
- Penicillium toxins.

Geographical distribution

The formation of mycotoxins in nature is considered a global problem. However, in certain geographical areas of the world, some mycotoxins are produced more readily than others.

Aflatoxins, the most widespread of all the mycotoxins, are common in warm and humid climatic conditions like those existing in the Asia-Pacific.

Extensive surveys conducted in India and Pakistan have suggested that aflatoxins are often encountered in appreciable levels in feeds and feed ingredients.

However, during the winter season in these countries high moisture conditions may result in other mycotoxins such as zearalenone, vomitoxin, T-2 toxin and ochratoxin.

In effect, aflatoxins, zearalenone, deoxynivalenol, fumonisin B1, ochratoxin A and T-2 toxins are commonly found in grains and grain byproducts of Asia-Pacific.

However, import of feedstuffs from other regions may slightly alter this profile at any given time point.

The increased movement of feedstuffs among different parts of the world is attributing an additional importance to the issue of mycotoxicoses. There can always be a significant difference between the levels of toxins at the point of import and of consumption.

Co-contamination feedstuffs

Mycotoxins in combination appear to exert greater negative impact on the health and productivity of livestock in comparison to their individual effects. Thus, feeds have been extensively surveyed for co-contamination of mycotoxins.

Separate surveys in China, South Korea, Taiwan and the erstwhile Soviet Union have suggested co-occurrence of mycotoxins with vary-

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ing degree of the frequency and levels of contamination among the different countries.

In a survey on sunflower oil cake in India, 8% of the samples were found to contain T-2 toxin and ochratoxin simultaneously. Similarly, Ravindran et al, (1996) reported co-occurrence of aflatoxin, fumonisin and zearalenone in Australian maize.

Impact of mycotoxins

Mycotoxins exert a wide variety of adverse effects on the health of dairy animals. From suppression of feed intake to digestive and reproductive disorders and immunosuppression, various negative effects are seen.

The major adverse effects of various mycotoxins acting individually or in combination may include one or more of the following:

- Decreased feed intake, production.
- Immunosuppression (decreased antibody titer values).
- Increased susceptibility to diseases.
- Damage to organs (liver, kidney and reproductive organs).
- Poor reproductive performance (decreased fertility, vulvovaginitis, repeat breeders, abortion and udder enlargement).
- Human health hazard due to mycotoxin residues in animal products.

Aflatoxins cause liver damage and are also important due to carryover into milk. Ochratoxins are mostly degraded in the rumen and, therefore, are not quite significant in dairy. Vomitoxin and T-2 toxin cause digestive disorders and laminitis.

Zearalenone causes hyper oestrogen response. Ergot, patulin and other penicillium toxins are known to mainly cause nervous symptoms among dairy animals.

Zearalenone has an oestrogenic effect on dairy animals. Zearalenone binds on to the cytoplasmic oestrogen receptor triggering a heightened oestrogen response.

Some symptoms of zearalenone toxicosis are uterine enlargement, swollen vulva and mammary glands, decline in ovulation rate and cycle length. Conception rate is decreased in dairy heifers. The oestrogenic effect of zearalenone is mediated by binding of mycotoxin to the cytoplasmic oestrogen receptor.

The mycotoxins causing immunosuppression in dairy animals (in decreasing order of severity):

- Aflatoxin.
- Vomitoxin and T-2 toxin.
- Fumonisin B1.

Mycotoxin residues in milk

The transfer of aflatoxin B1 metabolite into milk as aflatoxin M1 is a major issue affecting the safety and

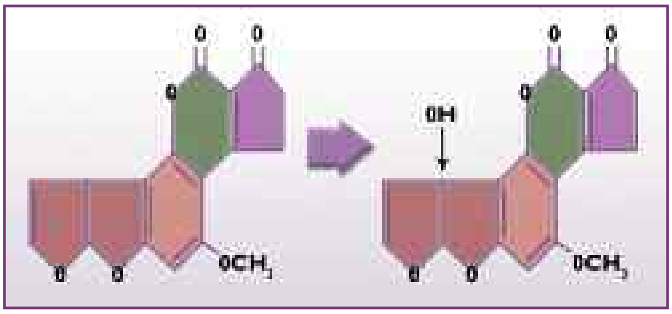


Fig. 3. Carryover of aflatoxin B1 into milk as aflatoxin M1.

quality of milk as well as tradeability of milk. Even though other metabolites such as aflatoxin M2, M4, Q1 and aflatoxicol are found in milk, aflatoxin M1 is the primary residue.

Regulatory recommendations and awareness among the producers have helped minimise aflatoxin problems. However, the ever tightening regulatory limits have been an issue of contention in the international trade.

To see a comparison, the FDA limit on in-feed aflatoxin B1 is 20ppb and for aflatoxin M1 in milk is 0.5ppb.

Assuming a 1.7% carryover rate for aflatoxin B1, the aflatoxin M1 content in milk would be 0.34 which is well within the limit.

A diet with 30ppb of aflatoxin B1 however would result in a carryover rate of in excess of 0.5ppb which would be rejected.

However, in the EU where 5ppb is the legally allowed limit, even with an assumed low carryover rate of 1%, the carryover into milk would be 0.05ppb which is to be rejected.

Other mycotoxins

Currently, aflatoxin B1 is the only mycotoxin which has a statutory regulation on the carryover into milk. For other mycotoxins, there are yet no regulatory limits on the metabolites in milk, nevertheless, they may be imposed in the days to come.

- Deoxynivalenol. DON is changed to DOM-1 in the rumen with estimates of 24 hour degradation of about 50%. However, the transfer rate and impact are not significant as the carryover is 0.0001% of the consumed toxin.
- Zearalenone. Carryover from feed into milk is variable and is insignificant.
- T-2 toxin. Residues of T-2 and its derivatives have been found in milk, but have a low transfer rate from feed to milk.
- Fumonisin. Fumonisin B1 carryover from feed to milk is thought to be negligible.

Studies with cattle fed oral dosage of fumonisin equivalent to 60-300ppm of dietary concentration have resulted in milk with no detectable fumonisins (detection limit 0.5ppb). Therefore, fumonisin can occur in milk, but is likely to be at very low levels.

Alleviate adverse effects

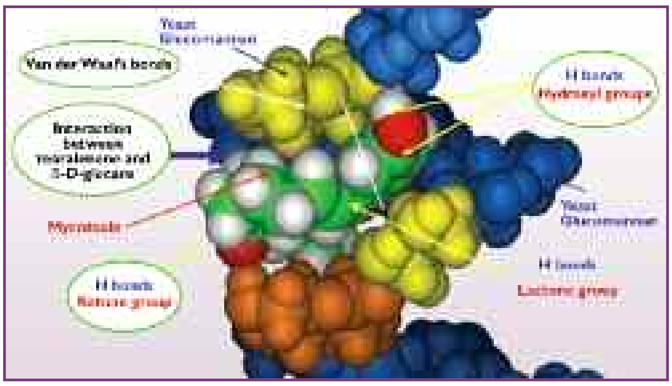
There is no available technology which can fully prevent the mycotoxin contamination of dairy feeds at pre-harvest or post-harvest times. However, in food animal feeds several methods of mycotoxin decontamination have been tried and are proven to be effective at varying levels.

The most effective method of neutralising mycotoxins already present in the feed is by binding them to an inert compound before they can be absorbed from the intestines.

Bentonites and aluminosilicate clays have been in use at different dose rates of 0.25-1.25% with varying efficacy against different mycotoxins.

Bentonites have been even shown to reduce aflatoxin M1 carryover into milk in animals fed diets con-

Fig. 4. Yeast glucomannan – structure and mode of action.



taining aflatoxin B1 to a considerable extent. However, these clays have disadvantages including high inclusion rates and a narrow range of binding efficacy as only aflatoxins are bound significantly. Clays tend to offer little or no protection against zearalenone and trichothecenes.

Yeast glucomannan (YGM), a biotechnological concept which is also organic, is a promising alternative that has gained acceptance in recent years. A derivative of the yeast cell wall, YGM has been shown to decontaminate several mycotoxins occurring in dairy feedstuffs.

Several researchers have proved that the YGM is able to bind higher levels of several important mycotoxins at a lower inclusion rates.

Some interesting recent research findings of adsorption of mycotoxins by YGM are presented below:

- Yiannikouris et al, (2005) at National Institute for Agricultural Research (INRA), France, have shown the key interactions between mycotoxins and yeast glucomannan.

Advanced molecular techniques were used to elucidate the molecular sites of interaction between mycotoxins and beta-D-glucans.

- Yeast glucomannan was shown to reduce milk aflatoxin concentrations by 58% in dairy cows consuming aflatoxin contaminated diets when included at 0.05% (0.5kg per ton) of the diet dry matter.

The reduction in milk aflatoxin may be a good indicator of strong binding with dietary aflatoxin, reducing aflatoxin absorption through the intestine of the cattle.

- In a field trial the addition of yeast glucomannan to the feed containing aflatoxin B1 improved the milk production and reduced the aflatoxin M1 residues in the milk by 65%.
- Supplementation of yeast glucomannan was shown to reduce somatic cell count in milk.

Summary

The dairy industry in the Asia Pacific has a very good scope for growth. Mycotoxins would be the major deterrents in exploiting this growth potential.

Application of suitable strategies to counter the mycotoxins would go a long way in promoting the dairy industry in this region.

The most appropriate strategies appear to be:

- Prevention of fungal growth on crops in the field, at harvest of crop, during storage of feedstuffs and processing of feed.
- Time to think is not when production is at its lowest but at the time of purchase of raw materials and storage, so that mycotoxin levels can be limited to a minimum.
- Application of appropriate mycotoxin binder in order to achieve good productivity and economy. ■