Quality silage and contamination by mycotoxins

In dairy cow diets, forages are the most important components representing more than 60% of the total daily feed intake. In order to increase nutritive values and digestibility of forages, corn silage is now widely used worldwide for its high and uniform nutritional quality (1.5 MCal/kg DM on average), ease of cultivation and high yields (up to three times more dry matter per hectare than grass).

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But many research studies observed that corn silage is the main contributor of mycotoxins ingested by cows. A survey run in 24 Dutch farms revealed that mycotoxins ingestion from ensiled forage was three times greater than for other feed ingredients.

A review of literature concludes that the total amount of mycotoxins from corn silage is often higher than the maximum concentrations allowed or recommended by authorities.

Several factors contribute to the high contaminations found in corn silage: higher development of moulds in stem and leaves compared to cob, conditions of harvest, storage conditions. Corn silage is often contaminated by a mixture of pre-harvest and post-harvest mycotoxins depending on temperature, water activity (aw), oxygen availability and pH conditions.

Typical mould growth in a dry silage (>35% DM), potentially producing mycotoxins.

Pre-harvest conditions

Pre-harvest or field moulds develop during plant growth and maturation as humidity is high (>70%) and temperature fluctuates between days and nights, Fusarium being the major field species.

Cold, wet periods followed by dry periods favour the development of Fusarium graminearum, nivale, culmorum, poae and roseum mainly producing deoxynivalenol (DON) and zearalenone (ZEA).

Fusarium proliferatum and verticillioides mostly develop during hot and dry periods (higher temperature than Fusarium sp producing DON) followed by humid conditions. This leads to Fusarium ear rot, a major corn plant disease which produces fumonisins. Weather conditions play a major role in the production of mycotoxins in the field.

Many studies reveal that DON is the most frequent mycotoxin in corn silage and can be used as a marker of Fusarium mycotoxin occurrence.

ZEA co-occurs with DON as they are both produced by Fusarium graminearum but surveys show that ZEA is often detected at lower levels than DON. Other Fusarium mycotoxins (enniatins, beauvericins, fusaric acids and moniliformin) are commonly detected but with a lower occurrence and level of contamination.

During very hot periods (>32°C), high humidity or drought stress, Aspergillus flavus can develop in the field even if Aspergillus are more known as post-harvest moulds.

Some cultivation methods have been identified for their impact on Fusarium development like selection of resistant varieties, management of crop residues, rotation, use of irrigation system to prevent drought, proper fertilisation and spread of pesticides (with public health concern) or bio-agents.

Insect damage can significantly increase contamination in Fusarium toxins and aflatoxins as it predisposes corn to fungal diseases.

Harvest conditions

No specific mould or mycotoxin develops specifically at harvest, but harvest conditions must be well adjusted to minimise aggravating conditions.

Several studies suggest that harvesting corn at an ideal dry matter, ranging from 30-35%, contributes to a reduced mycotoxin concentration, probably due to less time in the field compared with high-maturity plants and also because dry silage is more difficult

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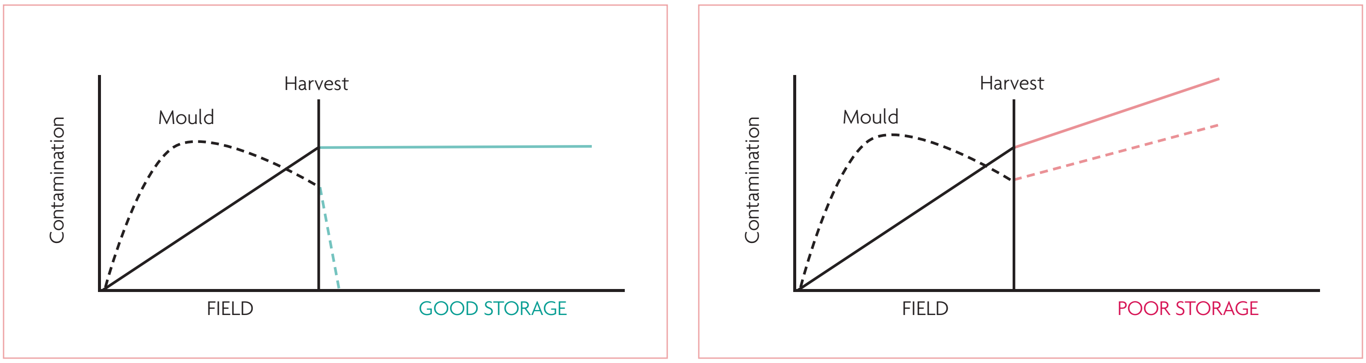
Fig. 1. Fusarium mould and toxins growth during post-harvest in silages (adapted from Wambacq et al., 2016 and Boudra et al., 2009). Development of mould (– – –) and production of mycotoxin (——) depending on silage storage conditions.



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to compact so more predisposed to the presence of oxygen and heating leading to mould growth.

It is also highly recommended to quickly seal silage to optimise anaerobic conditions. The cutting height must also be well adjusted to minimise soil contamination that is rich in Fusarium inoculum.

Post-harvest conditions

Post-harvest moulds generally grow under lower water activity levels compared to pre-harvest moulds. During storage, many spontaneous moulds can develop but not necessarily produce mycotoxins, meaning that the presence of moulds is not a reliable indicator of mycotoxin contamination.

Aspergillus and Penicillium are the two main strains of post-harvest moulds that develop in the presence of oxygen. Aspergillus is more frequent in tropical and sub-tropical regions as it prefers higher temperatures and mostly produces aflatoxins.

Aflatoxin occurrence is generally lower than other mycotoxins in well-preserved silages, whereas high concentration of aflatoxin can occur when silages are stored in poor conditions.

Aflatoxins are often quantified in feed materials as they are of particular concern regarding human health. In fact, aflatoxins are the only mycotoxins that can be significantly transferred into milk in addition to being highly carcinogenic.

Penicillium moulds can grow under lower temperature, oxygen and pH conditions compared to Aspergillus.

Mycophenolic acid and roquefortines remain the major mycotoxins produced by Penicillium, whereas the PR toxin and patulin are rarely detected.

Optimum storage conditions (low pH and anaerobic conditions) dramatically reduces the production of mycotoxins during storage as most mould species are intolerant to low oxygen and acidic conditions.

In 2008, Gonzales-Pereyra et al. demonstrated that poor compaction, poor sealing, and low feed-out rate promotes aerobic conditions and favours the growth of toxic moulds. It is strongly recommended to maintain a firm silo face, to feed-out at a rate of 10-16cm/day and to seal the silo with an oxygen film in order to limit mycotoxin production.

When storage conditions are not optimum, inoculum of pre-harvest moulds like Fusarium will find favourable conditions for their proliferation, leading to an

important accumulation of Fusarium toxins in the final diet (Fig. 1).

The use of preserving additives, such as inoculant or organic acids, will help to secure storage conditions and prevent toxin production at post-harvest but will not have any impact on toxins produced prior to harvest.

Consequences and protection

It is now clear that most of the mycotoxins found in corn silage are already present prior to harvest, thus Fusarium mycotoxins are the most occurring mycotoxins in dairy cows' diet, DON and fumonisins being the major ones.

Fusarium toxins exert their effects through three primary mechanisms in dairy cattle: immunosuppression, reduction in feed efficacy and gut integrity, and alteration of reproductive performance.

These three primary mechanisms, even with a low level of mycotoxins, provoke pathologies such as decreased performance, lower body condition, liquid faeces, increased somatic cells counts and mastitis, lameness, etc.

Even if good silage management prevents the growth of moulds and toxins during the post-harvest phase, it is very difficult to control Fusarium and toxin production prior to harvest.

As a consequence, Fusarium toxins constitute a major threat to dairy health and performance, and the use of a wide spectrum toxin binder, in addition to good silage practices, will efficiently protect dairy herds. ■

References are available from the author on request