GERMAN FEDERAL INSTITUTE FOR RISK ASSESSMENT

Fate of mycotoxins in cereal by-products used as feed materials

Bundesinstitut für Risikobewertung

Sara Schaarschmidt, Monika Lahrssen-Wiederholt, Carsten Fauhl-Hassek

German Federal Institute for Risk Assessment (BfR), Department Safety in the Food Chain, Berlin, Germany

Background

By-products of the cereal based food-production are often used as feed materials. During primary processing of cereal grains, however, mycotoxins are redistributed with typically elevated toxin concentrations in the by-products. To ensure animal welfare and to avoid excessive transfer of mycotoxins to foods of animal origin, the European Union (EU) decided on maximum and guidance levels for certain mycotoxins in products intended for animal feeding (see table below). Maximum levels for feed materials and compound feeds are set for aflatoxin B1 [1]. Guidance levels for cereal feed materials and/or for compound feeds are laid down for ochratoxin A and for the *Fusarium* toxins fumonisins B1 + B2 (for maize products only), deoxynivalenol, and zearalenone. For T-2 + HT-2 toxins, guidance and indicative levels were provided [2,3]. Mycotoxins are also regulated in the unprocessed grain used for food production. Here, mycotoxin maximum levels usually apply to the cleaned grain [4].

EU public standards for maize and wheat (by-products)	Mycotoxin levels in µg/kg			
	Unprocessed cereals for food production	Feed materials	**Factor** (level in feed material to level in unprocessed grain)	Complementary and complete feed
Aflatoxin B1 (AFB1)	Maize: 5 [a]	20 [b]	Maize: 4	5–20 [b]
Ochratoxin A (OTA)	5 [a]	250 [c]	50	10–100 [c]
Fumonisins B1 + B2 (FB1+FB2)	Maize*: 4,000 [a]	Maize: 60,000 [c]	Maize: 15	5,000–50,000 [c]
Deoxynivalenol (DON)	Maize*: 1,750 [a] Durum wheat: 1,750 [a] Other wheat: 1,250 [a]	Maize: 12,000 [c] Wheat: 8,000 [c]	Maize: 6.6 Durum wheat: 4.6 Other wheat: 6.4	900–5,000 [c]
Zearalenone (ZEN)	Maize*: 350 [a] Wheat: 100 [a]	Maize: 3,000 [c] Wheat: 2,000 [c]	Maize: 8.6 Wheat: 20	100–500 [c]
T-2 + HT-2	100 [d]	500 [d]	5	50 [c]–250 [d]

[a] Maximum level according to Commission Regulation (EC) No 1881/2006 and amending regulations [4]
[b] Maximum level relative to a feed with a moisture content of 12%; Directive 2002/32/EC and amendments [1]
[c] Guidance level relative to a feed with a moisture content of 12%; Commission Recommendation 2006/576/EC and amendments [2]
[d] Indicative level from which onwards/ above which investigations should be performed; Commission Recommendation 2013/165/EU [3]
* Except maize intended to be processed by wet milling only

Summary and conclusions

- The fate of mycotoxins during dry and wet milling was analysed based on data from the literature. The by-products typically show elevated mycotoxin levels compared to the raw grain.
- A compliance assessment was performed for milling by-products by comparing the changes in mycotoxin concentrations with the factors underlying the EU limits or recommendations from unprocessed cereals to feed materials.
- When unprocessed grain is near the legal limit, compliance might be challenging for maize by-products of dry milling, particularly in view of AFB1.
- Both maize and wheat by-products of dry milling can contain 5-fold to >10-fold higher levels of T-2 and HT-2 than whole grain; hence, contaminations above the indicative level are likely.
- Solid by-products of wet milling show no enrichment of water-soluble mycotoxins (FB1/2, DON). But mycotoxins can additionally be added into the feed with liquid fractions.
- For some processes and mycotoxins only few studies were found in the literature. More (robust) data will help to improve the knowledge on the fate of mycotoxins in by-products of food processing.
- In general, particular attention has to be paid to cereal by-products fed directly to the animals that their use in a daily ration should not lead to a higher mycotoxin exposure compared to the sole use of complete food in a daily ration.

Results – Literature study and compliance assessment for milling by-products

The diagrams show changes in mycotoxin concentrations in milling by-products as factor compared to the unprocessed (usually cleaned) grain as described in the literature, covering commercial and experimental milling procedures. Columns indicate approximate ranges of lots, lines represent approximate mean values for individual literature studies.

y-axis: Factor > 1 represents an enrichment in mycotoxin levels in this fraction compared to whole grain.

x-axis: The numbers refer to the literature studies; data obtained by different technologies or at different scale of processing are shown separately.

Red lines indicate the factors underlying the maximum and guidance (or indicative) levels from unprocessed (cleaned) cereals to cereal feed materials in the EU (see table above, column 4). Values above the lines indicate potential challenges in compliance.

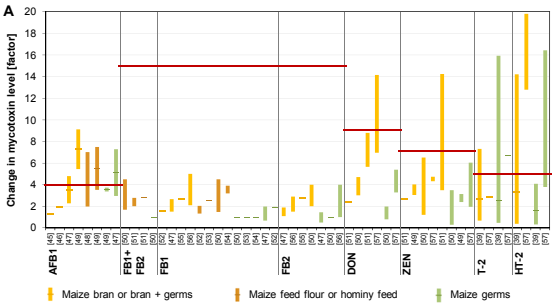
For example, as shown in Figure A:

- For AFB1, maize by-products of dry milling are often found to have approx. 2- to 7-fold higher levels than whole maize kernels.
- Here, the factor underlying the legal requirements is 4 (red line in diagram).
- This means that if the raw maize has an AFB1 level near the EU legal limit (5 µg/kg), the dry-milling by-products of maize might likely exceed the maximum level for feed materials (20 µg/kg).

Further details on the impact of maize and wheat processing on mycotoxins were recently published by the authors (Schaarschmidt & Fauhl-Hassek 2018 Compr Rev Food Sci Food Saf 17:556-593; Schaarschmidt & Fauhl-Hassek 2019 Toxins 11:227).

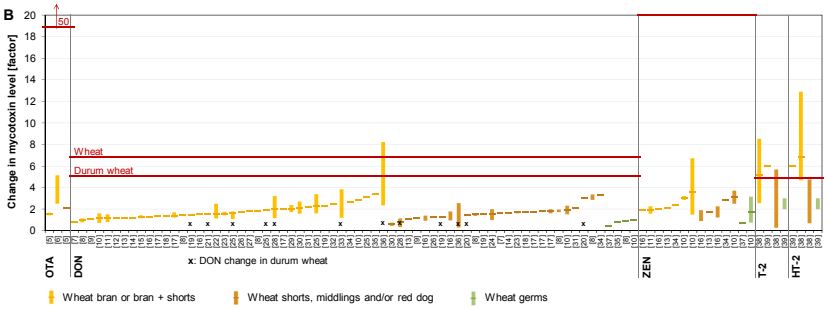
Maize

Dry milling



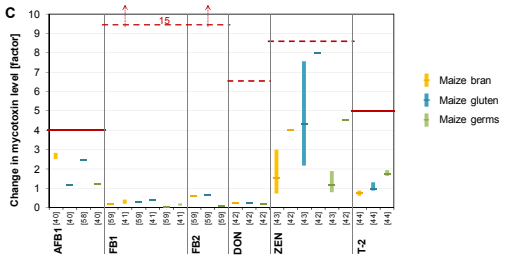
Wheat

Dry milling

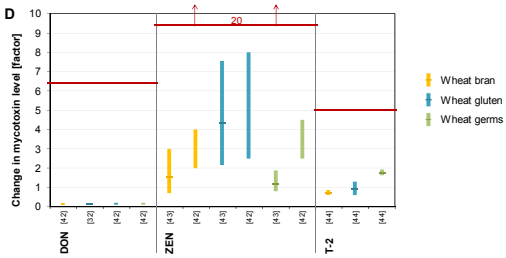


By-products of dry milling are usually characterised by higher mycotoxin concentrations compared to the whole grain.
Available data indicate potential challenges regarding the compliance of maize by-products with legal obligations/recommendations, particularly for AFB1 and DON.
In addition, monitoring of T-2 and HT-2 is recommended for wheat and maize by-products of dry milling.

Wet milling



Wet milling



Fractionation during wet milling depends on the water solubility of the mycotoxins. Soluble toxins (FB1/2, DON) show reductions in solid fractions, but typically accumulate in the process water (not shown here). This accumulation needs to be taken into account, when the concentrated steep liquor is used as feed material (as part of the gluten feed).
Maize intended for use in a wet-milling process may contain higher initial levels of fumonisins, DON, and ZEN. Thus, the dashed red lines are only an orientation.

References
The list of references is available here:

Photo sources:
Wheat grains: © Digitalpress / Fotolia
Maize grains: © M.studio / Fotolia

The work was performed as part of the MyToolBox project (www.mytoolbox.eu), which has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 678012.

German Federal Institute for Risk Assessment • Max-Dohrn-Str. 8-10 • 10589 Berlin, GERMANY • Phone +49 30-18412-0 • Fax +49 30-18412-99 0 99 • bfr@bfr.bund.de • www.bfr.bund.de/en