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Deoxynivalenol and fumonisins during the production of wheat bread and cornflakes

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Background

In cereal plants, *Fusarium* spp. are widespread pathogens that can cause mycotoxin contaminations in cereal-based foods. Major *Fusarium* mycotoxins are fumonisins, which are suggested to act as tumour promoters, and trichothecenes. The most prevalent trichothecene is deoxynivalenol (DON) that act as inhibitor of protein synthesis and can lead to acute gastrointestinal symptoms including nausea, vomiting, and diarrhea. To avoid acute and chronic affections of consumers' health, maximum levels (MLs) are set in the European Union (EU) by Commission Regulation 1881/2006 and amending regulations [1]. The limits depend on the mycotoxin, the cereal, and its grade of processing. For fumonisins, MLs for the sum of fumonisin B1 and B2 (FB1 and FB2) are laid down.

Here, the potential effects of wheat and maize processing in the production of bread and cornflakes (as described in literature) are depicted and compared with the changes in the EU legal limits. It should be noted that MLs are defined on an "as is" basis, whereas studies analysing the survival of mycotoxins during food processing usually provide data that are corrected for changes in moisture and composition. Thus, also dilution or concentration effects are displayed below.

DON in wheat bread production – Processing factors* and dilution/concentration effects** –

EU ML for unprocessed wheat, except durum wheat (uncleaned or cleaned): **1,250 µg/kg** [1]

Cleaning/sorting: ~0.1–0.9; often ~0.5–0.7 [2-11]

Milling to **white flour**: **~0.4–0.9**; often **~0.6–0.7** [8-19]

Wholemeal flour: no reduction

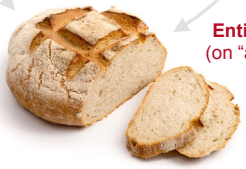
Fermentation: ~0.45–**1**–1.45 [9,19-23]

↓ Flour content: **~0.9**

↓ Dilution by higher moisture: **~0.7**

~0.5–1 [8-9,19-21,24-25]

Baking: **~0.7–1** [9,19-21]



Entire process (on "as is" basis, estimated): **~0.2–0.6**

EU ML for bread: **500 µg/kg** [1]

Factor to grains: 0.4

FB1/FB2 in cornflakes production – Processing factors* and dilution/concentration effects** –

EU ML for unprocessed maize (uncleaned or cleaned): **4,000 µg/kg** [1]

Cleaning: ~0.3–0.9; often ~0.7 [26-28]

Milling to flour: **~0.3–1**; often **~0.75-1** [28-32]

Milling to grits: **~0.05–0.15** [28-32]

EU ML for maize milling products ≤ 500 µm (not used for direct human consumption): **2,000 µg/kg** [1]

Factor to grains: 0.5

EU ML for maize milling products > 500 µm (not used for direct human consumption): **1,400 µg/kg** [1]

Factor to grains: 0.35

Extrusion cooking: **~0.08–0.9**; often **<0.5** [33-38]

Pressure cooking: **~0.1–0.65** [32-33]

Roasting: **~0.24–0.8** [32-33]

↓ Maize content: **~0.6–0.98**

↑ Concentration by lower moisture: **~1.1**

Roasting: **~0.24–0.8** [32-33]

EU ML for maize-based breakfast cereals: **800 µg/kg** [1]

Factor to grains: 0.2

Entire process (on "as is" basis, estimated): **approx. ≤0.1–0.4**

*: Change in the mycotoxin concentration during the indicated processing step(s) given as ratio of final to initial; if not mentioned otherwise, data are corrected for changes in moisture and composition

**: Estimated dilution (↓) or concentration (↑) by changes in moisture or composition given as factor

➲ EU ML for *Fusarium* mycotoxins in unprocessed cereals can also apply to cleaned cereals since cleaning including scouring, sorting, and drying procedures are not considered to be 'first-stage processing' in so far as the whole grain remains intact [1]

➲ (Cleaning was described to lower the DON load in wheat on average by ~0.7% to ~80%, often by ~30–50% [2-11])

➲ Milling can redistribute mycotoxins that are usually more common in the bran fraction; white wheat flour was shown to contain on average ~55–90%, often ~60–70% of the DON found in whole grains [10-19]

➲ Fermentation might release bound DON or reduce the level; baking can degrade a small part; both processes together were found to rather reduce the DON level compared to flour [9,19-21, 24-25]

➲ Bread production is accompanied by an increase in moisture (from ~12–14% to ~35–40%); the content of fat and sugar is less than 10 parts by weight per 90 parts by weight flour

➲ **When applying good practices, the overall reduction in DON from wheat grains to white bread is estimated to meet the legal limit; this can be more challenging for wholemeal bread** as well as for low-moisture high-flour bakery products (particularly when containing bran/wholemeal)

➲ (Cleaning of maize was described to reduce fumonisins often by around 30% on average [26-28])

➲ Larger maize endosperm particles are usually less contaminated than fine particles [28-32] thus specific FB1+FB2 MLs are laid down in the EU [1]

➲ Cornflakes can be produced from grits by conventional pressure cooking as well as by extrusion cooking of maize flour; both processes have a high potential to reduce fumonisin contaminations to below 50% [32-38]

➲ After cooking and flaking, roasting of the cornflakes using high dry heat is described to further lower the fumonisin load [32-33], in industrial processing by ~70% [32]

➲ Cornflakes are produced with different sugar contents (without added sugar up to a sugar content of around 40%) leading to a different degree of dilution; to ensure crispiness, the water content in the final product is very low (reduced from ~12–14% to usually ≤4%)

➲ **The overall reduction in the FB1+FB2 level from maize grains to cornflakes appears in most cases sufficient to meet the legal limit, although reduction will be less when flakes are produced from flour and with low sugar content**

References
The list of references is available here:

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