In 2016, the European Union’s (EU) Rapid Alert System for Food and Feed (RASFF) noted 39% of the total EU border rejections were due to mycotoxin contamination exceeding the maximum allowable limits. With latest state-of-the-art multi-analyte methods based on liquid chromatography/mass spectrometry (LC-MS/MS), a huge number of samples are tested positive for mycotoxins. For instance, 72% of analyzed crops were found to be contaminated with one or more mycotoxins in a recent study covering more than 17,000 samples. Taking advantage of the power of LC-MS/MS, various conjugated (masked) mycotoxins have been detected, which indicates an array of ambiguous contamination conditions and metabolisation processes. Similar challenges are envisaged for phycotoxins, of which new analogs were found, in addition to changes in the global occurrence of phycotoxins.

Climate change adds to the complexity of new challenges regarding the occurrence of natural toxins. Accepting that climate change is a reality, the Intergovernmental Panel on Climate Change (IPCC) found that increasing temperatures, frequencies and duration of extreme weather events, and elevated CO₂ and ozone concentrations in the atmosphere are likely to also impact the quality of food. However, research on the effects of climate change on the occurrence of natural toxins and, more specifically, the subsequent analytical challenges, remains limited despite the pressing need for standardized analytical methodologies for monitoring, predicting and managing all of these risks. The current situation requires novel and fully integrated approaches which involve all actors in the food and feed chains. This overall objective is being pursued in the current EU-funded H2020 project MyToolBox (www.mytoolbox.eu, grant agreement no. 678012).

Impact of climate change
Climatic parameters, such as temperature, precipitation and extreme weather events influence the growth of mycotoxin-producing fungi and the range of metabolites produced by these. As a result of global warming, Bebber and colleagues forecasted a pole-wards shift of plant pathogens and pests at about 3-5 km per year. Hence, certain mycotoxins are detected in locations where they have hardly occurred before, e.g. aflatoxin B1 in central Europe. This is illustrated by the Serbian maize scandal of 2013 among others: Due to extended periods of drought and overall 2 °C increase of mean temperature, *Aspergillus* spp. found an optimum environment for growth. As a result, more than 4000 farmers in Lower Saxony, Germany, were supplied with such contaminated Serbian maize for feed, in which aflatoxin B1 concentrations were up to 30 times higher than the allowed maximum level in the European Union.

The growth of phycotoxin-producing algae is also influenced by rising temperatures and the increasing CO₂ level in the atmosphere. In terms of phycotoxin determination, monitoring of water quality for evaluating the potential of algal bloom is of increasing importance.

Impact of advanced mass spectrometry
To determine phycotoxins, mouse bioassays were applied predominantly in the past. However, during the last decade a shift to liquid-chromatographic methods and LC-MS/MS based multi-toxin methods was recorded. Regarding the determination of phycotoxins a big challenge is the large number of congeners that result in complex chromatograms. Another, equally critical, limiting factor is the lack of reference standards, in particular certified reference materials.
The European Food Safety Authority (EFSA) has developed a series of scientific opinions concerning marine biotoxins, including groups currently regulated in the EU legislation and emerging toxins which become a new global health risk due to their prevalence in new geographical regions. These toxins include ciguatoxins, palitoxins and brevetoxins and the recently discovered cyclic imines. Regulated phycotoxins are monitored regularly with validated methodologies based on multi-analyte LC-MS/MS based methods to decrease the risk of human intoxication. New guidelines indicating how to manage the new risks are needed.

During the last decade, there has been a clear trend towards the development and application of multi-analyte methods based on LC-MS/MS for the assessment of both, mycotoxin occurrence and exposure to these biotoxins. One of such methods includes the identification of 295 bacterial and fungal metabolites, including all regulated mycotoxins. Both climate change as well as advances in high-performing analytical methods such as LC-MS/MS, seem to have an impact on the increasing detection of unexpected occurrence of mycotoxins in food and feed. The analysis of 76 oat samples from southern parts of Norway showed more than 40 different secondary metabolites at unusual concentration rates of up to 7230 µg/kg of deoxynivalenol and up to 333 µg/kg of HT-2-toxin. The authors associated these results with improvements in LC-MS methods as well as with climatic changes. Recently, non-targeted LC-MS based metabolomics has been successfully employed for the unbiased detection of yet unknown secondary metabolites of fungi and further metabolisation products of plants.

Utilizing the power of advanced mass spectrometric methods, traces of mycotoxins and relevant breakdown and conjugation products can be quantified simultaneously in human urine as so-called biomarkers and can be used to precisely describe the real exposure, toxicokinetics, and bioavailability of the toxins present.

Conclusions

In conclusion, climate change clearly impacts on the occurrence of various fungi and algae and thus on their metabolite balance. Extreme weather events such as heat, drought and intense precipitation can lead to unexpected mould-infestation and algal blooms. Consequently, these issues can further lead to increasing occurrence of “emerging toxins” and to high concentrations of specific natural toxins in regions not usually affected by these. In addition, the risk of paralytic shellfish toxins and cyanobacterial blooms increases with rising surface temperatures of the seas and freshwater bodies. These challenges will increase the demand for LC-MS/MS-based methods to examine a broad spectrum of potential toxic compounds in the food-production chain as well as of toxin-biomarkers in urine. Such methods will significantly contribute to improved individual exposure assessment. High performance metabolomics based methods will play an increasingly important role regarding the study of plant-fungi-interactions, and thus for the detection of new metabolites emerging as a result of global warming and changing environmental conditions.

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